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A NEW AND COMPLETE DESCRIPTION OF THE TERRESTRIAL and CELESTIAL GLOBES, With their ſeveral USES.

In EIGHT PARTS.

CONTAINING

I. Definitions of the ſeveral Parts of the Celeſtial and Terreſtrial Globes, both real and imaginary, with their ſeveral Uſes.

II. A ſhort but comprehenſive Syſtem of the Geography of the Terreſtrial Globe.

III. The Uſe of the Terreſtrial Globe, exemplified or illuſtrated in Sixty-eight Problems, with very eaſy Directions for working them.

IV. The Conſtruction of the *Analemma*, with its Uſe on the Terreſtrial Globe, in Seven Problems.

V. A further Uſe of the Terreſtrial Globe, exemplified in Forty-five Theorems, with their Explications.

VI. A Continuation of the Uſe of the Terreſtrial Globe, exemplified in Fifty-ſix Paradoxes, with their Solutions; diſtinguiſhed into Geographical, Philoſophical, and Aſtronomical.

VII. The Uſe of the Celeſtial Globe, exemplified in Twenty-ſix Problems, with very eaſy Directions to obtain their Solutions, to which is prefixed a ſhort Account of the *Copernican* Syſtem, and a ſhort Explanation of the latter Part of Parker's Ephemeris.

VIII. A Continuation of the Uſe of the Celeſtial Globe, exemplified in Twelve Nautical Problems, for finding the Latitude at Sea; with the like eaſy Solutions.

To which is annexed,

An APPENDIX, Concerning the Nature and Uſe of the ORRERY, OR PLANETARIUM.

The Whole, interſperſed with uſeful and inſtructive *Notes*, is deſigned and adapted for the Uſe of Schools, in *Great-Britain* and *Ireland*; and in the *Britiſh Colonies* and *Plantations* abroad.

By THOMAS DILWORTH,
Schoolmaſter in *Wapping*; Author of the New Guide to the English Tongue, Schoolmasters Assistant, &c. &c.

LONDON:
Printed and Sold by Richard and Henry Causton, at the Printing-Office, N° 21, in *Finch-Lane*, near the *Royal Exchange*, MDCCLXXV.

BRITISH MUSEUM

TO

WILLIAM MOUNTAINE, *Eſq;*
F. R. S.

SIR,

HAVING ſubmitted the following Pages to your impartial Peruſal, and afterwards received from You the agreeable Aſſent, that they are what the Title-Page expreſſes, *viz. A new and complete Deſcription of the* GLOBES, *with their ſeveral Uſes,* I am conſtrained to beg this further Favour, that you would take them under Your friendly Protection in this public Manner; and the more ſo, ſince You was pleaſed to add a great many uſeful Informations, not thought of, by me, before; therein preſenting You with Your own again.

Your Knowledge of the GLOBES, and of their Uſefulneſs in Geographical and Aſtronomical Studies, emboldens me to think, that I am not wrong in the Choice of ſuch a Patron; and the many Gentlemen, who have, from You, received their Mathematical Erudition, when this Book ſhall come into their Hands, will (I doubt not) confirm that Choice. And however, ſenſible they may be of the Obligations conferred on them, by Your building them up in every Branch of Mathematical Knowledge, yet none are more ſo, than,

SIR,

Your moſt obliged, and

Moſt humble Servant,

Thomas Dilworth.

THE PREFACE.

AMIDST the ſeveral Branches of Education, which are taught in our Schools, that of the GLOBES is none of the leaſt: And amidſt the ſeveral Treatiſes that have, from time to time, been handed down to us, not one that I have ſeen can be called complete; ſome being very prolix in ſuch Parts as require very little expatiating on, I mean the Geographical Part; and others being very defective with regard to the Definitions, Theorems, Paradoxes and Problems, which ought to be, in a particular Manner, enlarged on, in Order to render a Pupil at School, or any other Perſon deſirous of knowing the Uſe of the GLOBES, thoroughly acquainted with them: And it was this, together with the difficulty of a Teacher's providing written Papers, to give them a complete Inſtruction, which put me upon compoſing the following Pages. How well I have ſucceeded in this Undertaking beyond any who have trod this Path before me, I ſhall leave to better Judges to determin.

The Study of the GLOBES is exceeding pleaſant, inaſmuch as it furniſhes the Learner with very ſurprizing and lively Ideas of the Heavens and of the Earth: and it is not only pleaſant but profitable, as it aſſiſts him in ſuch of his Mathematical Studies as relate to Aſtronomy.

In this Attempt of mine, I have obſerved the Order mentioned in the Title Page, *viz.*

1. I have given the uſual Definitions of the ſeveral Parts of both GLOBES, both real and imaginary, wherein the ſeveral Uſes of thoſe Parts are laid down for the Information of the Learner.

2. A Geographical Account of the Terreſtrial GLOBE is next exhibited, wherein I have been very ſhort, becauſe the GLOBE itſelf confined me to be ſo: The Nature of a Terreſtrial GLOBE of 16 Inches Diameter (which is large enough for common Uſe) not admitting of a larger Account; neither can a complete Courſe of Geography be ſtudied ſo well on the largeſt Terreſtrial GLOBE, as

from Treatiſes wrote profeſſedly on that Subject, joined with a Sett of the largeſt two-ſheet Maps.

The GLOBES, which I have all along uſed, are thoſe of the late Mr. *Price's* Conſtruction, or go by his Name; being, as I obſerved before, 16 Inches in Diameter. Not out of Oppoſition to thoſe made by Mr. *Senex* (which are without all Doubt very good) but by Friendſhip, it being many Years ſince I purchaſed them.

3. The Learner is next preſented with a Sett of 68 Problems on the Terreſtrial GLOBE; the Solutions of which are laid down by ſuch eaſy Directions, that the Teacher may communicate with fewer Words, and conſequently the Learner will make a quicker Progreſs by this Method than by any other. If the Teacher ſhould want more Examples, as it is poſſible he may for ſome Pupils, it will be very eaſy for him to enlarge in every Problem, by varying it, where he finds it neceſſary.

4. I have introduced the Uſe of the *Analemma* on the Terreſtrial GLOBE, with the Way of conſtructing it for GLOBES of all Sizes. A thing not commonly uſed, tho' very entertaining.

5. The ſeveral Geographical Theorems, that I occaſionally met with (principally taken from Mr. *Gordon's* Geographical Grammar) I have here inſerted; and becauſe I thought them alone very imperfect for a Learner, notwithſtanding, that they are certain and undeniable Truths, I have given an Explication to every one of them; and here I promiſe to give the Learner a great deal of Benefit. For, when his Tutor has explained them to him, whether by this Book or off-hand, with the GLOBE before him, the Learner by reading them and applying them to the GLOBE again, cannot but be greatly informed, and his Judgment thereby very much ſtrengthened.

6. Next after the foregoing Theorems and their Explications, I have given all the Paradoxes that Mr. *Gordon* obliged the World with, together with a few of my own. And tho' the ſeveral Solutions to thoſe Paradoxes were given by another Hand (Mr. *Gordon* not chuſing to give them himſelf, but left them to the Learners to perform, which by the Way, was an Omiſſion, and which led them into inextricable Mazes) I have given them again *de novo*, diſ-

tinguiſhing them into *Geographical*, *Philoſophical* and *Aſtronomical*. And here I conceive the Learner will receive another Benefit, and that none of the ſmalleſt. For, as many of them are ſo dark, that it is next to impoſſible for him to give a true Solution, without being firſt informed by his Tutor: ſo after ſuch Information received, by applying to the GLOBE, with theſe Solutions, he will be very much aſſiſted. Beſides, the Tutor in his ſeveral Leſſons, will be obliged to make ſome little Experiments himſelf to help his Pupil's Underſtanding; and therefore theſe Solutions, by making the Pupil read them at the GLOBE, will ſave the Teacher much Trouble and many Words, at the ſame Time that they will be a Benefit to the Scholar.

And as Paradoxes as well as Theorems, are in themſelves certain infallible Truths, tho' expreſſed in Terms ſeemingly contradictory and inconſiſtent, and condemned by ſome, yet they cannot be clearly underſtood without a good Knowledge of the Uſe of the Terreſtrial GLOBE (and perhaps of the real GLOBE of the Earth too, which, if not attained by travelling, may be by Hiſtory) and may be properly called ſo many Touch-ſtones, ſerving to whet the Genius of a Reader, inquiſitive after this pleaſing and uſeful kind of Learning.

7. Next, in Order, I have given a ſhort Account of the Celeſtial GLOBE, and of the Conceptions a Perſon ſhould have at the Time he compares it with the Heavens; alſo of the Syſtem of the Univerſe, or as it is commonly called the *Solar* or *Copernican Syſtem*, together with ſome Particularities of the Sun, Moon, Earth and Planets. And herein I muſt beg leave to obſerve that I have not been very circumſtantial about the Planetary Syſtem, but have only mentioned it in general Terms, becauſe the Planets cannot be depicted upon the GLOBE, they every Day changing their Places, being ſometimes in one Sign, and ſometimes in another. — Particular Accounts of them and alſo of Eclipſes being to be met with in all or moſt Aſtronomical Writers.

The fixed Stars, as they are ranged into Conſtellations are here exhibited in the narrow Compaſs of Tables taken from Mr. *Robertſon's* excellent Elements of Navigation; yet as full as others, who have in Treatiſes of this Nature expreſſed themſelves in a much larger Manner; including a ſhort Account of the *Via Lactea*, and of *Nebulous Stars*.

8. The Reader is preſented with a Sett of 26 Aſtronomical Problems on the Celeſtial GLOBE, and 12 Nautical Problems for finding the Latitude at Sea. And here I would have it obſerved, that if, upon working any of the following Problems, the Anſwer ſhould not be exactly the ſame with what is there exhibited, it muſt be attributed partly to the Differences of GLOBES, and partly to the Differences of Workmen; ſince what with one Difference, and what with the other, it is hardly poſſible to make two GLOBES ſo exactly alike, that they ſhall admit of the ſame preciſe Anſwer. Add to theſe, the Want of a true Light, in a School; which, when it happens to be the Caſe, is another Objection towards the obtaining a juſt Solution. Now, all theſe put together, it is no Wonder, if, upon working any Problem by either of the GLOBES, that *that* particular Solution does not appear in ſo exact a Manner, as that, which is affixed to the Problem to which it belongs.

9. If the Number of *Problems*, *Theorems* and *Paradoxes* ſhould be objected, as being too large, and therefore needleſs, I anſwer, that I think there is not one too many, inaſmuch as other Treatiſes upon the GLOBES are by far too ſhort, notwithſtanding their Author's ſay, that by offering about twenty or thirty Problems, without any Explanation of either *Theorems* or *Paradoxes*, there are enough of them; and that others not mentioned in their ſeveral Treatiſes, may eaſily be underſtood, by thoſe that are.

10. And laſtly; To all the foregoing Articles, I have added an Appendix, concerning the Nature and Uſe of an *Orrery*, or *Planetarium*; which is an Inſtrument repreſenting the *Copernican Syſtem*; ſo fit to be introduced into Schools, and ſo eaſy to be underſtood, both by Ladies as well as young Gentlemen, that I am ſurprized it is not ſo much taught as it deſerves. I preſume, I need ſay no more upon the whole, in this Place, but leave the following Sheets to ſpeak for themſelves: If they contribute any thing towards the Improvement of a promiſing Genius, it will give a great Pleaſure to the Author, and I am ſure it muſt be ſome Advantage to the Learners, inaſmuch as they will furniſh young Minds with ſuch exalted Ideas, as cannot be found, where nothing of this Kind is ſtudied.

A new and complete

DESCRIPTION
Of the TERRESTRIAL and CELESTIAL
GLOBES,
With their ſeveral USES.

PART I.

Containing Definitions of the ſeveral Parts of the GLOBES, both real and imaginary, with their Uſes.

Of the GLOBES in general.

GLOBES are artificial ſpherical Bodies, made to repreſent the Heavens and the Earth.

They are of two Sorts, viz. *terreſtrial* and *celeſtial*; each of which are compoſed of the following Parts, ſome *real*, and ſome *imaginary*.

I. *Of the* real *Parts, and their Uſes.*

1. The *Globe* or round Ball itſelf, which is an Emblem, one of the Heavens, and the other of the Earth; whereon are placed (on the terreſtrial Globe) the ſeveral Parts of the Earth and Sea, in their natural Situation; and (on the celeſtial Globe) the Stars of Heaven, under the Figures of Men, Birds, Beaſts, and ſeveral other Repreſentations; and on both, ſeveral Circles, ſome running parallel to each other, which are called Parallels of Latitude or Declination; and others croſſing each other in oppoſite Points at the Poles, which are called Meridians, or Circles of right Aſcenſion.

2. The *Horizon*; which is a broad flat Piece of Wood, running round the Globe, called the rational true, or aſtronomic Horizon, and ſerves

(1.) To divide the Globe into two equal Parts, called the upper and lower Hemiſpheres.

(2.) To determin the Times of the riſing and ſetting of the Sun, Moon, and Stars, their Altitudes, and Continuance above the Horizon.

(3.) To ſhew the Length and Increaſe of Day and Night, in all Places of the Earth, by Inſpection.

The *Horizon* contains ſeveral ſignificant Circles, *viz.* The

(1.) Or that which is outermoſt, ſhews the ſeveral Points of the Compaſs, each Point having its Name. The

(2.) Shews the *Julian* Calendar, or old Account of Time, as it ſtood before that Calendar was reformed in the Year 1752. The

(3.) Diſcovers the New Calendar, as it is now uſed in *England*, and by Foreigners; in which are wrote the ſeveral reſpective Saints Days, and other remarkable Days, fixed againſt their reſpective Days of the Month, which are diſtinguiſhed in a ſmaller Circle inwards; the two Calendars anſwering to each other Day by Day exactly, but with this Difference, that the new Calendar ſtands eleven Days before the old one. The

(4.) Shews the 12 Signs of the Zodiac, each Sign being divided into three Parts; firſt the Name, then the Character, and laſtly the Sign itſelf, as depicted on the Celeſtial Globe; the two laſt being radiated for Diſtinction's Sake. On an inner ſmall Circle the Degrees of each Sign are diſtinguiſhed, by 10, 20, 30; in another inner ſmall Circle, by ſingle Degrees; and in another, the ſmalleſt of all, each Degree is ſubdivided into three Parts, *viz.* 20 Minutes each.

3. The *Brazen Meridian*, or great Braſs-Ring; which ſerves to divide the Globe into two equal Parts, called the Eaſtern and Weſtern Hemiſpheres.

This Circle is divided into four Quadrants; two of which begin at the Equator, and increaſe in Degrees towards the Poles, to ſhew the North and South Latitude of Places on the Terreſtrial Globe, and the Declination of the Sun and Stars on the Celeſtial Globe. The other two Quadrants begin at the Poles, and increaſe in Degrees towards the Equator, and theſe ſerve to elevate and depreſs either of the Poles to the Latitude of any particular Place.

Note 1. The Poles of this *Meridian* are in the Eaſt and Weſt Points of the Horizon.
2. *Meridian* is derived from the *Latin* Word *Meridies*, *South*, or rather from *Medidies*, or *Medius-dies*, the Middle of the Day; becauſe when the Sun comes to that Circle, it is at that very Moment, Noon, Mid-day, or 12 o'Clock.

4. The *horary Circle*, or *Hour-Circle*: This is a ſmall flat Ring of Braſs, generally fixed about the North Pole, becauſe more frequently uſed in North than in South Latitude. On this Ring are deſcribed the twice 12, or 24 Hours of the natural Day: that twelfth Hour which is uppermoſt, and next the Zenith, repreſents 12 o'Clock at Noon; the lowermoſt 12, repreſents the Hour of 12 at Night: The Hours, on the Eaſtern Side, ſhew the Morning Hours, that is, from Midnight to Noon; and thoſe on the Weſtern Side, ſhew the Afternoon Hours, that is, from Noon to Midnight: Every Hour alſo anſwers to 15 Degrees of the Equator, and by that means reduces the Degrees of the Equator or Equinoctial into Time, and the contrary, at once: It alſo ſerves to ſhew the Hour of the Sun's, Moon's, and any particular Star's riſing, Culminating or Southing, and ſetting; and ſeveral other Purpoſes.

Note 1. The Pole of the Globe is always in the Center of this *Circle*.
2. The Index or Hand, which points to the Hour, is carried round by the Motion of the Globe, either Eaſterly or Weſterly; it being fixed on the Axis of the Globe, which is made to project itſelf beyond the Braſs-Meridian for that Purpoſe; yet at the ſame time is capable of being put to any Hour propoſed, without moving the Globe.
3. *Horary* is derived from the *Latin* Word *Hora*, an *Hour*.

5. The *Quadrant of Altitude:* This is a narrow, thin, pliant Plate of Braſs, exactly anſwering to a Quadrant of the Brazen Meridian; and, like that, is divided into 90 Degrees, having a Nut and Screw at one End to faſten it to the Meridian (always in the Zenith) and, when fixed, ſupplies the Place of an infinite Number of vertical Circles: It alſo ſerves to determin the Altitudes, Azimuths and Diſtances of the Celeſtial Bodies, on the Celeſtial Globe, and the Diſtance and Bearings of Places, *&c.* on the Terreſtrial Globe.

Note, The Degrees are reckoned upwards on this *Inſtrument*, becauſe all Altitudes on the Globes begin at the Horizon, and are reckoned towards the Zenith.

6. The *Semicircle of Poſition:* This is a thin Plate of Braſs, anſwering to one half of the Horizon, and is divided into 180 Degrees; and, when uſed, is fixed at the North and South Sides of the Horizon or Meridian: It ſerves to meaſure the Diſtance between any two Places, on the Surface of the Terreſtrial Globe, or between any two Stars on the Celeſtial Globe, which are beyond the Reach of the Quadrant of Altitude. However, as the Quadrant of Altitude or Horizon, in a great Meaſure, ſupplies the Want of this Inſtrument, it is not uſually made, except deſired.

7. The *Wires* upon which the artificial Globe turns: Theſe repreſent the two Poles of the World, *viz.* North and South; and alſo the Axis, upon which the great Fabric of the terraqueous or natural Globe moves, in its diurnal Motion from Weſt to Eaſt.

8. The *Mariners Compaſs:* This does not immediately belong to the Globe, but is neceſſary, by placing it on the Horizon, or elſewhere, to put the Globe in ſuch a Poſition, as to ſtand due North and South, to repreſent the Face of the Earth or Heavens, according to the given Situation; but to do this yet more accurately, Care muſt be taken to allow for the Variation.

II. *Of the* imaginary *Parts, and their Uſes.*

1. The *Horizon.* This, upon the artificial Globes, is a material Circle, yet, upon the Globe of the Earth, is only an imaginary one, and always moveable: It is of two Kinds, *viz.* Senſible and Rational.

The ſenſible, or natural *Horizon*, is that Circle that bounds the Sight of every individual round about, where the Earth and Sky, or Water and Sky, ſeem to meet.

The true rational, or mathematical *Horizon*, divides the Globe of the Earth into two equal Parts, called the upper and lower Hemiſpheres, and to which all aſtronomical Calculations refer.

The natural, ſenſible, or apparent *Horizon*, is of a greater or leſs Extent, as the Eye is nearer to, or farther from the Surface of the terraqueous Globe. Thus the Eye, which is five Feet above the Ground, will ſee 2.745 Miles ſtraight forwards, and no more, admitting the Ground to be level all the Way; and if the Proſpect ſhould be extended further, as very often it is, this is owing to riſing Ground, which makes the Curve turn upwards, whereas the Curve, on even Ground, is always downward. Now the Truth of the juſt mentioned Obſervation will appear very plainly thus.

1. The Globe of the Earth, or any great Circle, is 360 Degrees round.

2. Every Degree is 69.5 Miles, Statute-Meaſure.

3. Every ſuch Mile contains 1760 Yards, or 5280 Feet.

4. If 360 be multiplied by 69.5, it will give 25020 Statute Miles round the Globe.

5. If the following Proportion be admitted, *viz.*

22 : 7 : : 25020 : 7960

it will give 7960 Miles for the Earth's Diameter, which reduced into Feet gives 42028800.

6. Put b for the Diameter of the Earth in Feet, and c for the Height of the Eye above the Surface of it in Feet alſo, you have this general Theorem, *viz.* $\sqrt{\overline{b+c}\times c}$; the Reſult of which is equal to the Semidiameter of the ſenſible *Horizon* = 2.745 Miles: Hence, if the Eye be 5 Feet from the Ground, it will ſee ſtraight forward 2.745 Miles, as fully appears by turning the aboveſaid Theorem into Numbers; thus,

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      42028800 = b = the Earth's Diameter in Feet.
            ×5 = c = the Height of the Eye above the Ground.
   ------------
      42021805
            ×5
   ------------  3       17610
   210144025(14496(48312(2.745 Miles.
   1                 352
   ---               ----
24)110               1312
    96               1232
   ----              ----
284)1414              800
    1136              704
    -----             ----
2889)27840            960
     26001            880
    ------            ----
28986)183925           80
      173916           --
      ------
       10009
      ------
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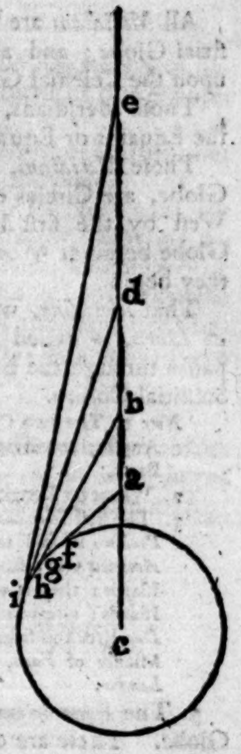
7. If the Eye be 10 Feet from the Ground, it will ſee ſtraight forward 3.882 Miles.

8. If the Eye be 20 Feet from the Ground, it will ſee ſtraight forward 5.49 Miles. And

9. If the Eye be 40 Feet from the Ground, it will ſee ſtraight forward 7.765 Miles.



Now that the Eye being raiſed above the Ground higher and higher, will ſee farther and farther, will yet more plainly appear, from the Diagram in the Margin.

Let a Circle be made at Pleaſure, to repreſent the Earth's Surface. Then raiſe the Perpendicular [c e] and extend it at Pleaſure.

Let [a] be the firſt Height from the Surface, and draw [a f] to touch the ſaid Circle at the greateſt Diſtance. Let [b] = double the Height of [a] be the next Height; then draw [b g] in ſuch manner that the Point [g] may touch the Circle at its greateſt Diſtance alſo: Hence it appears, that the Eye being placed at [b] will ſee farther than an Eye placed at [a] becauſe it is higher: The ſame may be ſaid of an Eye placed at [d] which will ſee to [h]; and another at [e] which will ſee to [i]. Hence Mariners are furniſhed with a ready Method of finding the Diſtance of Land from the Ship at Sea, when firſt diſcovered, if ſuch Land be not elevated; for the Height of the Eye at the Maſt-head from the Water, will always be a given Number, as well as the Earth's Diameter in Feet.

Though the riſing and ſetting of all the Luminaries have reſpect to the rational *Horizon*; yet, becauſe of their great Diſtance, it holds true ſufficiently of the ſenſible *Horizon* alſo, notwithſtanding its being above 4000 Miles above the rational *Horizon*; the Moon excepted, becauſe of her nearneſs to the Earth.

Note, The Poles of the rational and ſenſible *Horizons* are in the Zenith and Nadir of the Obſerver.

2. The *Meridians*. Theſe, though they are, upon the Globes, reduced to one, which is the *Braſs-Meridian*, are nevertheleſs imaginary, numberleſs, and moveable, becauſe every Place has its *Meridian*. Theſe *Meridians* cut each other obliquely in the Poles (except thoſe at a quadrantal Diſtance) and the Equator or Equinoctial at right Angles.

When the Sun comes to the *Meridian* of any Place, it is always Midday; and in the Torrid Zone is ſometimes due South, ſometimes due North, and ſometimes vertical at Noon; but in the Temperate and Frigid Zones, in North Latitude, it is due South, and in South Latitude due North at Noon; and at the Point of Interſection in the North Pole, the Sun is always due South; and at the like Point of Interſection in the South Pole, the Sun is always due North, let the Hour be what it will.

The *Meridian* of any Place is the 12 o'Clock Hour-Line for that Place, except directly at the two Poles.

When the Sun, Moon, and Stars, come to the *Meridian* of any Place, they are then, with reſpect to that Place, at the higheſt; and all of them, as ſoon as they have paſſed that *Meridian*, begin to decline and go down.

All *Meridians* are repreſented by the Braſs-Meridian upon the Terreſtrial Globe; and all Circles of right Aſcenſion, by the like Meridian upon the Celeſtial Globe.

Thoſe Meridians, which are drawn through every fifteenth Degree of the Equator or Equinoctial, are called Hour-circles.

Thoſe *Meridians*, which ſtand at every tenth Degree on the Terreſtrial Globe, are Circles of terreſtrial Longitude, and are divided into Eaſt and Weſt by the firſt *Meridian*, which is at *London*; and on the Celeſtial Globe begin at ♈ *Aries*, and go quite round Eaſterly, till they end where they begin.

That *Meridian*, which paſſes through the beginning of ♈ *Aries* and ♎ *Libra*, is called the Equinoctial Colure: and that *Meridian* which paſſes through the beginning of ♋ *Cancer* and ♑ *Capricorn*, is called the Solſtitial Colure.

Note 1. The two Colures, juſt mentioned, cut one another in the Poles at right Angles, and divide both the Ecliptic, and Equator or Equinoctial, into four equal Parts.

2. Wherever Longitude begins, that is called the firſt *Meridian*.

3. The firſt *Meridian* has, by ſome, paſſed over one Place, by ſome, over another. *Ptolomy* is ſaid to have placed it one Degree beyond the *Canary* Iſlands: After *America* was diſcovered, it was placed at *St. Nicholas*, one of the *Cape de Verde* Iſlands: then it was fixed, by *Hondius*, at *St. Jago*, another of the *Cape de Verde* Iſlands: afterwards, by *Mercator*, at *Corvo*, one of the Weſtern Iſlands. The *Dutch* reckon from *Teneriffe*, one of the *Canary* Iſlands; the *French* place it in the Middle of *Faro*, the weſtermoſt of the *Canary* Iſlands; and the *Engliſh* at *London*.

3. The *Equator* on the Terreſtrial Globe, and *Equinoctial* on the Celeſtial Globe. Theſe are one and the ſame thing, that is, the *Equator* indefinitely extended, and divide the Globe into two equal Parts, called the Northern and Southern Hemiſpheres; they being every Way diſtant from the Poles juſt 90 Degrees; conſequently the Poles of theſe two Circles are the Poles of the Globes.

When the Sun is *here*, the Days and Nights are equal to all the Inhabitants of the Earth, except at the two Poles; alſo the Sun, Moon, and ſuch of the Stars as are upon this *Line*, always riſe due Eaſt, and ſet due Weſt.

This *Circle* is divided into twice 180 Degrees on the Terreſtrial Globe; one Way numbered Eaſtward from the firſt Meridian, which paſſes thro' *London*, and the other Way Weſtward from it, till theſe two Reckonings meet on the oppoſite Side of the Globe, on the ſame Circle. On the Celeſtial Globe, the Equinoctial is divided into 360 Degrees quite round, beginning at the Point ♈ *Aries*, where the Ecliptic and Equinoctial interſect each other. One Revolution of the Equator, from Weſt to Eaſt, meaſures the natural Day, conſiſtiag of 24 Hours: and hence the following little Table (which may be enlarged at Pleaſure, by the Pupil, to every Degree and Minute) is formed, *viz.*

°.	*m.*	*ſ.*		*hrs.*	*m.*	*ſ.*	
360	0	0	*of the Equator moves in*	24	0	0	*of Time.*
15	0	0	- - - - - - - -	1	0	0	
1	0	0	- - - - - - - -	0	4	0	
0	15	0	- - - - - - - -	0	1	0	
0	1	0	- - - - - - - -	0	0	4	

Upon this Circle are reckoned the right and oblique Aſcenſions of the Sun and Stars, on the Celeſtial Globe, and the Longitudes of Places upon the Terreſtrial one.

The Declination of the Sun, Moon and Stars, and the Latitudes of Places, begin here, both which are reckoned upon a *Meridian*.

Now, as the whole Body of the Earth turns upon its *Axis* with the rapid Motion of 15 Miles in one Minute, at the Equator, allowing 60 Miles or Minutes to a Degree, or 17.375 Statute Miles, allowing 69.5 Miles to a Degree: Many pretty Queſtions might be propoſed by the Tutor, concerning the Motion of the Earth on any of the Parallels of Latitude, and how many Miles will paſs in any propoſed Time, in any given Latitude. Thus,

EXAMPLES.

The Globe of the Earth is 360 Degrees, and each Degree 69.5 Miles upon the Equator: Now, as the Earth turns quite round once in 24 Hours; how many Miles, on the Equator, may paſs in one Minute?

$$\frac{360}{24} = 15^\circ \textit{ which paſs in 1 Hour.}$$

$$\frac{15 \times 69.5}{60} = 17,375 \textit{ Miles, which paſs in 1 Minute.}$$

Or thus,

Making 60 Miles = 1 Degree, according to common computation.

$$\frac{360}{24} = 15^\circ = 900 \textit{ Miles, as above.}$$

$$\frac{900}{60} = 15 \textit{ Miles, which paſs in 1 Minute.}$$

But as Circles are ſmaller, the nearer they are to their Poles, I demand how many Miles on the Tropic of *Cancer* may paſs in one Minute: where about 55 Statute Miles make a Degree?

$$\frac{360 \times 55}{24} = 825 \textit{ Miles which paſs in 1 Hour.}$$

$$\frac{825}{60} = 13.75 \textit{ Miles, which paſs in 1 Minute.}$$

How many Miles paſs in one Minute on the Parallel of *London*, where about 37 Miles make a Degree?

$$\frac{360 \times 37}{24} = 555 \textit{ Miles, which paſs in 1 Hour.}$$

$$\frac{555}{60} = 9.25 \textit{ Miles, which paſs in 1 Minute.}$$

How many Miles, at the Polar Circles, paſs in 1 Minute, where 27 Miles make a Degree?

$$\frac{360 \times 27}{24} = 405 \textit{ Miles, which paſs in 1 Hour.}$$

$$\frac{405}{60} = 6.75 \textit{ Miles, which paſs in 1 Minute.}$$

Note, Whatever the Paſſage is in any Degree of Latitude, on one Side of the Equator, it is juſt the ſame, in the like Degree of Latitude, on the other Side.

4. The *Ecliptic.* This is a great Circle, which cuts the Equator in two oppoſite Points, *viz.* ♈ *Aries,* and ♎ *Libra,* called Equinoctial Points, and forms an Angle (according to Mr. *Flamſteed)* equal to 23° 29′ which is the Sun's greateſt Declination.

The Ecliptic is divided into 12 Parts called Signs, beginning at that Interſection of the Equator or Equinoctial which hath this Mark ♈ called *Aries.* The Signs are named and marked as follow, *viz.*

Northern Signs.

Spring	*Aries*	♈ the Ram	*March* *April.*
	Taurus	♉ the Bull	*April.* *May.*
	Gemini	♊ the Twins	*May.* *June.*
Summer	*Cancer*	♋ the Crab	*June.* *July.*
	Leo	♌ the Lion	*July* *Auguſt.*
	Virgo	♍ the Virgin	*Auguſt.* *September.*

Southern Signs.

Autumn	*Libra*	♎ the Balance	*September.* *October.*
	Scorpio	♏ the Scorpion	*October.* *November.*
	Sagittarius	♐ the Archer	*November.* *December.*
Winter	*Capricornus*	♑ the Goat	*December.* *January.*
	Aquarius	♒ the Water-bearer	*January.* *February.*
	Piſces	♓ the Fiſhes	*February.* *March.*

The firſt ſix are called *Northern Signs,* becauſe they are on the North Side of the Equator; the other ſix are called *Southern Signs,* becauſe they are on the South Side of the Equator.

Note 1. The Cardinal Points are the firſt Points of ♈, ♋, ♎ and ♑.

2. It is owing to this Diviſion of the Ecliptic, that the Sun's Place is readily diſcovered, and pointed out for any Day in the Year.

When the Sun is in or very near the Equinoxes, that is ♈ and ♎, the Days lengthen or ſhorten much; becauſe the *Ecliptic* in thoſe Places is moſt oblique to the Equator; but when the Sun is near to, or juſt entered the Solſtices, that is, the beginnings of ♋ and ♑, the Days ſcarcely alter at all, but ſeem to be at a Stand, becauſe in thoſe Places, the *Ecliptic* is almoſt parallel to the Equator.

The *Ecliptic* is ſo called, becauſe Eclipſes, both Solar and Lunar, always happen in this Circle. It is alſo called the *Via Solis,* or Sun's Way, becauſe the Sun is never out of it. One Revolution of the Sun, from any one Point in the Ecliptic, to the ſame Point again, is called a Tropical Year, conſiſting of 365 *Days*, 5 *hrs.* 48 *min.* 57 *ſec.* and makes our natural Year, conſiſting of 365 Days and 6 Hours, nearly.

> *Note*, Though it is ſaid that the Sun moves from one Sign to another, through the *Ecliptic*, it is underſtood to be ſo in Appearance only; becauſe as the Earth turns quite round from Weſt to Eaſt, upon its own Axis, once in 24 Hours, it therefore makes the Sun, and all the other Luminaries, to turn (in appearance) from Eaſt to Weſt; whereas, in fact, it is the Earth itſelf that rolls round the Sun, through the *Ecliptic*, from Weſt to Eaſt, at the ſame time that it turns upon its own Axis, the Sun, in the mean time, being at reſt, as to any circular Motion. Now, in order to find the Earth's Orbit round the Sun, and from thence the Quantity of his Motion daily, hourly, and minutely, the following Queſtion may be propoſed to the Pupil, *viz.*

The Semidiameter of the Earth is 3985 *Engliſh* Miles; and the Diſtance of the Earth from the Sun is 93,726,900 Miles: Now, as the Earth moves round the Sun once in a Year, how many Miles does it move in one Minute, and how many in one Second of Time, ſuppoſing it formed a complete Circle, and moved regularly?

Put s for the Earth's Semidiameter
d - - - - - Diſtance from the Sun.

Then $s + d = S$ = the Semidiameter of the Earth's Orbit.
$S \times 2 = D$ = the Diameter of the Earth's Orbit.

As $7 : 22 : : D : C = 589{,}165{,}563$ Miles, the Circumference of the Earth's Orbit, or the Earth's Motion in one Year.

$\frac{C}{365} = F = 1{,}614{,}152$ Miles, the Earth's Motion in one Day.

$\frac{F}{24} = G = 67{,}256$ Miles, the Earth's Motion in one Hour.

$\frac{G}{60} = H = 1120$ Miles, the Earth's Motion in one Minute.

$\frac{H}{60} = I = 18.7$ Miles, the Earth's Motion in one Second, or ſingle Beat of the Pendulum of a good Clock; which is a Velocity far ſuperior to that of the ſwifteſt Cannon Ball.

Again:

What is the great Orbit of the Earth round the Sun, ſuppoſing it moved with no other Force, than as it turns upon its own Axis once in 24 Hours, and ſo is repeated every Day, till it arrives in the ſame Point in the Heavens from whence it ſet out, which will be in $365\frac{1}{4}$ Days?

> *Note*, The Circumference of the Earth is 360 Degrees, and each Degree is 69 Miles $\frac{1}{2}$, conſequently the Earth is = 25020 Miles round. Once in 24 Hours the Earth turns round on its own Axis, which muſt be 25020 Miles. In one Year therefore, the Earth turns round 365 times and $\frac{1}{4}$; then it muſt be 365 times 25020 Miles, and $\frac{1}{4}$ of 25020; thus,

$$\begin{array}{l} 25020 \\ 365 \\ \hline 125100 \\ 150120 \\ 75060 \\ \hline 9192300 \\ 6255 = \tfrac{1}{4}\text{ of } 25020 \\ \hline \end{array}$$

9198555 Miles = the great Orbit of the Earth, which it runs in one Year round the Sun, according to this laſt Suppoſition.

Hence it appears, that this Orbit, great as it is, is not near ſo large as the former; and that the former *Calculus*, in all Probability, comes nearer to the Truth than this latter: If this be admited, it will farther appear, that the Earth is moved in its Orbit with another Force, beſides that which turns it upon its own Axis. For it is known by Obſervation, that the Earth turns round once in 24 Hours, which is juſt 25020 Miles; but it is moved with upwards of 64 times the Velocity, in its Orbit round the Sun, at the ſame time; ſomething like that of the Moon, which, though it has an Orbit of its own, round the Earth, has alſo another, at the ſame Time, round the Sun, with the Earth, and conſequently moves with a different Force from that round her own Axis; otherwiſe, were it not for that ſuperior Motion, the Earth's Orbit muſt contain no more than 365 times 25020 Miles, with the fourth Part of the Earth's Circumference added.

5. The *Zodiac*, This is a great Circle, 16 Degrees broad, running round the Globe, in which thoſe 12 Conſtellations are placed, which give Names to the 12 Signs: Exactly in the Middle of this broad Circle is the Ecliptic aforementioned; and in the whole of it, the Motion of the Sun, Moon, and the reſt of the Planets, are always performed, the Sun only keeping continually in the Middle.

Note, Zodiac is derived from the *Greek* Ζωὴ *vita*, or Ζάω *vivo*; hence Ζώδιον *Animalculum*; and hence Ζωδιακὸς *Zodiacus*, of or belonging to a living Creature or Animal; becauſe the Signs therein have ſuch Semblances: or becauſe it was anciently believed to afford Life and Heat to Animals.

6. The *Equinoctial Colure*. This is a Meridian which paſſes through the two Interſections of the Ecliptic and Equinoctial, in the firſt Points of ♈ and ♎.

7. The *Solſtitial Colure*. This is a Meridian, which cuts the Equinoctial Colure at right Angles in the Poles of the World, and paſſes through the two *Solſtices*, or firſt Points of ♋ and ♑.

Note, The two Colures, aforementioned, divide the Surface of the Globe into four equal Parts, and denote the four Seaſons of the Year, *viz.* Spring, Summer, Autumn, and Winter.

8. The *ſix o'Clock Hour-Line*. This is a Meridian which cuts the grand Meridian, or *twelve o'Clock Hour-Line* of any Place, at right Angles in the Poles of the World, and is moveable in the ſame Degree as that is. When the Sun, Moon and Stars are here, if they be on the Weſtern Side of the Meridian of any Place, they have then paſſed that Meridian

ſix Hours; but if they be on the Eaſtern Side of the ſame Meridian, they want ſix Hours of coming to it; the Moon differing from this Rule, becauſe of her Inequalities.

9. *Parallels of Terreſtial Latitude or Declination.* Theſe are ſuch as run parallel to the Equator, at the Diſtance of 10 Degrees from each other: When they are uſed with reſpect to the Sun, Moon and Stars, they are called *Parallels of Declination*; but when they are uſed with reſpect to Places, on the Terreſtrial Globe, they are called *Parallels of Latitude*.

Note, *Parallels of Latitude* may be made or imagined, not only to every Degree, but to every Minute of the Quadrant.

10. *Parallels of Celeſtial Latitude.* Theſe are Circles running parallel to the Ecliptic.

11. The *Tropic* of ♋. This is diſtant from the Equator 23° 29′ Northward, and is ſo called, becauſe it touches the Ecliptic in the firſt Point of ♋.

12. The *Tropic* of ♑. This is diſtant from the Equator 23° 29′ Southward, and is ſo called, becauſe it touches the Ecliptic in the firſt Point of ♑. Theſe two Tropics are the Boundaries of the Sun's Motion; beyond either of which it never paſſes.

Note 1. The *Tropics*, on the Celeſtial Globe, are Parallels of Declination, but on the Terreſtrial Globe are Parallels of Latitude.

2. *Tropic* ſignifies a Return, becauſe when the Sun comes to the firſt Points of ♋ and ♑, he immediately begins to return again to the Equinoctial, or appears ſo to do.

13. The *Artic Circle.* This is a ſmall Circle, diſtant from the North Pole 23° 29′. Thoſe Inhabitants who live any where within this Circle, never ſee the Sun when he is in the Tropic of ♑; ſuch excepted, who live near this Circle, and then by Refraction only.

14. The *Antarctic Circle.* This a ſmall Circle, diſtant from the South Pole 23° 29′. Thoſe Inhabitants who live any where within this Circle, never ſee the Sun when he is in the Tropic of ♋; ſuch excepted, who live near this Circle, and then by Refraction only.

Note 1. Theſe Circles are alſo called Polar Circles, becauſe of their Vicinity or nearneſs to the Poles: Or rather, becauſe the Poles of the Ecliptic are therein.

2. As the *North Polar Circle* paſſes through the Conſtellation *Arctos*, or the Bear, it is called the *Arctic Circle*.

3. The *South Polar Circle* is called the *Antarctic Circle*, becauſe it is directly oppoſite to the Arctic Circle.

4. Both theſe Circles and the Tropics are diſtinguiſhed on the Globes by double Lines, in order to make them the more remarkable.

15. The two *Poles* of the World. Theſe are two Points North and South of the Equator, and juſt 90° diſtant from it: They are diametrically oppoſite to each other, where the Meridians interſect one another.

16. The *Axis of the World.* This is a Line ſuppoſed to paſs through the Earth and both Poles, and to be infinitely extended both Ways: And this is the Line, round about which the Globe of the Earth turns, from Weſt to Eaſt, in 24 Hours.

17. *Zones.* Theſe are large Tracts of Land and Water on the Surface of the Globe, lying parallel to the Equator, and are diſtinguiſhed from

each other by the four leſſer Circles, *viz.* the two polar Circles, and the two tropical Circles. They are five in Number, *viz.*

(1.) The *Torrid* or *burning Zone*, which is all that Space round the Globe, lying between the Tropic of ♋, and the Tropic of ♑, and is divided in the midſt by the Equator.

(2.) The two *temperate Zones*; one of which contains all that Space, which lies between the Tropic of ♋ and the Arctic Circle, called the *North temperate Zone*; the other contains all that Space, which lies between the Tropic of ♑ and the Antarctic Circle, called the *South temperate Zone.*

(3.) The two *frigid* or *frozen Zones*; one of which contains all that Space within the Arctic Circle, called the *North frigid Zone*; the other contains all that Space within the Antarctic Circle, called the *South frigid Zone.*

18. *Climes* or *Climates.* Theſe are Tracts on the Surface of the Earth, bounded by imaginary Circles running parallel to the Equator, being 30 in Number, 24 of which are of ſuch a Breadth from South to North, that the Length of the artificial Day in one *Clime*, ſurpaſſeth that in the next *Clime* by only half an Hour: The other ſix differ by entire Months, each of them being one Month longer than the other.

A Table of Climates, *differing from each other half an Hour.*

Climates.	*Latitudes* °	′	*Longeſt Days hrs.*	*min.*	*Climates.*	*Latitudes* °	′	*Longeſt Days hrs.*	*min.*
0	0	0	12	0	13	59	58	18	30
1	8	25	12	30	14	61	18	19	0
2	16	25	13	0	15	62	25	19	30
3	23	50	13	30	16	63	22	20	0
4	30	20	14	0	17	64	6	20	30
5	36	28	14	30	18	64	49	21	0
6	41	22	15	0	19	65	21	21	30
7	45	29	15	30	20	65	47	22	0
8	49	1	16	0	21	66	6	22	30
9	51	58	16	30	22	66	20	23	0
10	54	27	17	0	23	66	28	23	30
11	56	37	17	30	24	66	31	24	0
12	58	29	18	0					

A Table of Climates, *differing from each other an entire Month.*

Climates.	*Latitudes* °	′	*Longeſt Days Months*	*Climates.*	*Latitudes* °	′	*Longeſt Days Months.*
25	67	15	1	28	78	20	4
26	69	30	2	29	84	10	5
27	73	20	3	30	90	0	6

The Conſtruction of the foregoing Tables.

Theſe Tables are made by continual Approaches with given Latitudes, till they make the longeſt Day juſt half an Hour longer than the preceding Climate. As for Example: Take a Globe of three Feet Diameter, whoſe Meridian has its Degrees divided into Minutes, and whoſe Hour-Circle has alſo Minutes joined to it; then by elevating the Globe to every Minute of Latitude, and bringing the Sun's Place from the Eaſtern to the Weſtern Horizon, the Indices will ſhew the Length of the longeſt Days, as will appear more plainly among the Problems following.

The Uſe of the foregoing Tables.

This is obvious from the Titles of the ſeveral Columns: For if you would know the Length of the longeſt Day in any particular Clime; or what Clime or Latitude belongs to ſuch a particular longeſt Day, it is eaſily known by Inſpection.

19. *Latitude* of a Place on the Earth, or *Terreſtrial Latitude*. This is the Quantity of an Arch of the Meridian of that Place, intercepted between the given Place and the Equator: Or it is the neareſt Diſtance of the given Place from the Equator towards either of the Poles, meaſured on the Brazen Meridian; and is of two Sorts, *viz.* North and South: North when on the North Side of the Equator, and South when on the South Side of it.

20. *Latitude* of any Point in the Heavens, or *Celeſtial Latitude*. This is the Quantity of an Arch of a Circle of Longitude, intercepted between that Point and the Ecliptic: Or it is the neareſt Diſtance of that Point from the Ecliptic; and is either North or South, as the Point is either on the North Side or South Side of the Ecliptic.

Note 1, *Celeſtial Latitude* begins at the Ecliptic, as *Terreſtrial Latitude* begins at the Equator.

2. As the Ecliptic and Equinoctial make an Angle of 23° 29': So the two Poles of the Ecliptic are at the ſame Diſtance from the like two Poles of the World.

21. *Longitude* of a Place on the Earth, or *Terreſtrial Longitude*. This is of two Sorts, *viz.* Eaſt and Weſt, and is the Quantity of an Arch of the Equator, intercepted between a certain Point where ſome fixed Meridian paſſes, which is called the firſt Meridian, and the Meridian of the given Place meaſured on the Equator; *i. e.* Eaſt, if it be on the Eaſt Side of the firſt Meridian, and Weſt, if it be on the Weſt Side of it: Or, it is the Angle at the Pole formed by the firſt Meridian, and that of the Place.

Note, That *Longitude* is not always the real Diſtance of Places one from another, is evident from two Places, taken at Pleaſure, in any Parallel of Latitude; ſuppoſe 76° North; and two more lying in the Parallel of 22° North, having the ſame Meridians paſſing through each two that lie North and South of each other; and all of them having the ſame firſt Meridian, which may, in this Caſe, be fixed any where at Pleaſure. Hence it will appear that the Longitudes of thoſe two Places in 76° is the ſame with thoſe two in 22°; yet thoſe two Places in 76° Latitude will be vaſtly nearer than the other two in the Latitude of 22°. And the Reaſon is very plain, becauſe the Meridians of the two places in 76° are nearer to each other than the ſame Meridians in the Latitude of 22°. Hence obſerve, that though every Circle contains 360°, yet every Degree does not contain 60 Minutes or Miles; for as the Circles grow ſmaller and ſmaller, the nearer they approach to the Poles; ſo the Diſtance between any two Places, though in the ſame Latitude, contains fewer and fewer Miles, as their Meridians approach nearer and nearer, till at laſt they all terminate in each Pole, which is evident from the following Table.

A TABLE *containing the Longitude, or Number of Miles and Decimal Parts of a Mile, anſwering to one Degree in every Degree of Latitude.*

Lat.	*Miles.*	*Lat.*	*Miles.*	*Lat.*	*Miles.*	*Lat.*	*Miles.*	*Lat.*	*Miles.*	*Lat.*	*Miles.*
0	60.00	16	57.67	32	50.88	48	40.15	64	26.30	80	10.42
1	59.99	17	57.38	33	50.32	49	39.36	65	25.36	81	9.38
2	59.96	18	57.06	34	49.74	50	38.57	66	24.40	82	8.35
3	59.92	19	56.73	35	49.15	51	37.76	67	23.45	83	7.31
4	59.86	20	56.38	36	48.54	52	36.94	68	22.48	84	6.27
5	59.77	21	56.01	37	47.92	53	36.11	69	21.50	85	5.22
6	59.67	22	55.63	38	47.28	54	35.27	70	20.52	86	4.18
7	59.56	23	55.23	39	46.63	55	34.41	71	19.53	87	3.14
8	59.42	24	54.81	40	45.96	56	33.55	72	18.54	88	2.09
9	59.26	25	54.38	41	45.28	57	32.68	73	17.54	89	1.04
10	59.09	26	53.93	42	44.59	58	31.79	74	16.54	90	0.00
11	58.89	27	53.46	43	43.88	59	30.90	75	15.53		
12	58.69	28	52.97	44	43.16	60	30.00	76	14.52		
13	58.46	29	52.48	45	42.43	61	29.09	77	13.50		
14	58.22	30	51.96	46	41.68	62	28.17	78	12.48		
15	57.95	31	51.43	47	40.92	63	27.24	79	11.45		

The Conſtruction of the foregoing Table.

A general Rule.

As Radius :
Is to the Logarithm of 60 : :
So is the Sine Complement of the given Latitude :
To the Miles in 1 Degree of Longitude in that Latitude.

Or thus, particularly.

As Radius - - - - - - - - - - - - 10.0000000

Is to the Logarithm of 60 - - - - - - 1.7781513
So is the Sine Complement of 1 Degree - 9.9999338

To the Logarithm of 59.99 - - - - - - 1.7780851

The Uſe of the foregoing Table.

It is obvious, from the Direction at the Head of the Table, that it is calculated to ſhew how many Miles anſwer to a Degree of Longitude, in any Parallel of Latitude; as in the firſt Degree of Latitude, whether North or South, there are 59.99 Miles to a Degree of Longitude; the like of the reſt.

Note, The foregoing *Table* may eaſily be enlarged by the Pupil, at Pleaſure, to every Minute of the Quadrant, for his better Inſtruction.

22. *Longitude* of a Point in the Heavens, or *Celeſtial Longitude.* This is the Quantity of an Arch of the Ecliptic, intercepted between the firſt Point of ♈, and a Circle of Longitude paſſing through the given Point.

Note, *Celeſtial Longitude* is always reckoned from the firſt Point of ♈, and is not named *Eaſt Longitude* and *Weſt Longitude*, as on the terreſtrial Globe, but goes quite round the Ecliptic, from ♈ to ♋, from thence to ♎, from thence to ♑, and ſo on to ♈ again.

23. The *Right Aſcenſion* of any given Point in the Heavens. This is the Quantity of an Arch of the Equinoctial, intercepted between the firſt Point of ♈, and that Meridian paſſing through the given Point: Or, it is an Angle at the Poles formed by the Equinoctial Colure, and that Meridian paſſing through the given Point; and is meaſured upon the Equinoctial.

Note, Right Aſcenſion, on the Celeſtial Globe, is reckoned in like Manner as Longitude on the Terreſtrial Globe, and, like that, may be converted into Time.

24. The *Declination* of any given Point in the Heavens. This is the Quantity of an Arch of a Meridian, paſſing through that Point, intercepted between that Point and the Equinoctial, and is either North or South, according to the Side of the Equinoctial it is placed on.

25. The *oblique Aſcenſion* of any given Point in the Heavens. This is that Degree of the Equator which riſes with that Point in an oblique Sphere.

26. The *oblique Deſcenſion* of any given Point in the Heavens. This is that Degree of the Equator which ſets with that Point in an oblique Sphere.

27. The *aſcenſional Difference* of any celeſtial Object. This is the Difference between its *right* and *oblique Aſcenſions*. With regard to the Sun, it is the preciſe Time that he riſes or ſets before or after Six o'Clock.

28. The *Zenith* of a Place. This is ſuch a Point of the Heavens as is directly over it; and is the uppermoſt Pole of the Horizon of that Place, whether ſenſible or rational.

29. The *Nadir* of a Place. This is that Point of the Heavens which is directly under it; and is the lowermoſt Pole of the Horizon of that Place, whether ſenſible or rational.

Note, The *Zenith* and *Nadir* of any Place are Points, which are diametrically oppoſite to each other.

30. *Azimuths*, or *vertical Circles*. Theſe are great Circles perpendicular to the Horizon of a Place, and paſs through its Pole: Or it is the Quantity of an Angle contained between the Meridian and a vertical Circle, reckoned in Degrees on the Horizon, from the North or South Points, towards the Eaſt or Weſt.

Note, If the Quadrant of Altitude be laid over any particular Place, on the Surface of either of the Globes, it will diſcover its Azimuth on the Horizon.

31. The *prime Vertical*. This is that great Circle which paſſes through the Eaſt and Weſt Points of the Horizon, and is at right Angles with the Meridian of a Place, which is another vertical Circle paſſing through the North and South Points of the ſame Horizon.

32. The *Azimuth* of any celeſtial Object. This is an Angle at the Zenith of the Obſerver, or Place obſerved at, formed by the Meridian of

that Place, and a vertical Circle paſſing through the Object obſerved: Or, it is the Quantity of an Arch of the rational Horizon, intercepted between thoſe two Circles, and reckoned Northerly or Southerly from the Meridian.

33. The *Amplitude* of any celeſtial Object. This is an Angle made at the Zenith of the Obſerver, or Place obſerved at, by the Meridian of that Place, and a vertical Circle paſſing through the Center of the Object at its riſing or ſetting: Or, it is the Quantity of an Arch of the Horizon contained between the Center of that Object, juſt at its riſing or ſetting, and the Meridian of the Place obſerved at; and is reckoned from the Meridian, either Eaſterly or Weſterly.

Note, *Amplitude* is of two Sorts, *viz.* *Ortive* or Oriental, when the *Amplitude* is taken at the riſing of any heavenly Body; and *Occaſive* or Occidental, when the Amplitude is taken at the ſetting of the ſame.

34. The *Altitude* of any Object in the Heavens. This is the Quantity of the Arch of a vertical Circle, paſſing through the Center of that Object, intercepted between its Center and the Horizon.

35. The *Zenith-Diſtance* of any Object in the Heavens. This is the Quantity of an Arch of the vertical Circle, contained between the Center of that Object and the Zenith.

Note 1. *Zenith-Diſtance* and Altitude are Complements to each other, both together making 90°.

2. When the Zenith-Diſtance of an Object is juſt 90°, it is then in the Horizon, and is either juſt riſing or juſt ſetting, and therefore can have no Altitude.

3. When the *Altitude* of an Object is juſt 90°, it is then in the Zenith, and therefore can have no *Zenith-Diſtance*.

36. The *Meridian-Altitude* of an Object in the Heavens. This is the *Altitude* of that Object when it is on the *Meridian* of the Place obſerved at.

37. The *Meridian-Zenith-Diſtance* of an Object in the Heavens. This is the *Diſtance* of that Object from the *Zenith*, when it is on the *Meridian* of the Place obſerved at.

38. Any *great Circle* on the Surface of a Globe, divides it into two equal Parts; as, the Meridians, Equator, Ecliptic, *&c.*

39. A *ſmall Circle* divides the ſaid Surface into two unequal Parts; as the Tropics, Polar-Circles, *&c.*

40. Every *Circle*, whether great or ſmall, is imagined to be divided into 360 *Degrees*; every *Degree* into 60 *Minutes*; every *Minute* into 60 *Seconds*; every *Second* into 60 *Thirds*, and ſo on to *Fourths*, *Fifths*, *&c.*

41. The *Culminating* of any heavenly Object. This is the Time when it arrives at the Meridian of any Place obſerved at.

42. *Almicanters*, or with ſome *Almicanthers*. Theſe are Parallels of Altitude, being ſmall Circles, one above another, and always run parallel to the Horizon.

43. *Cardinal Points*. Theſe are the four principal Points of the Horizon, *viz.* *Eaſt*, *Weſt*, *North* and *South*.

Note, If a Line upon a Plane is drawn from Eaſt to Weſt, it is called a Parallel, becauſe parallel to the Equator: If from North to South it is called a Meridian, becauſe all Meridians run North and South

44. *Equinoctial Points*. Theſe are two Points where the Equator or Equinoctial, and the Ecliptic, interſect each other diametrically. The firſt is in the firſt Point of ♈, and is called the *vernal Equinox*, becauſe,

when the Sun is here, it is the Beginning of the *Spring-Quarter*: the ſecond is in the firſt Point of ♎, and is called the *Autumnal Equinox*, becauſe, when the Sun is here, it is the beginning of Autumn.

45. *Circles of Celeſtial Longitude.* Theſe are great Circles, which paſs through the Poles of the Ecliptic, and cut it at right Angles. They are uſually drawn through every Sign, or 30°, and divide the whole Surface of the Celeſtial Globe into twelve equal Parts.

46. *Circles of Celeſtial Latitude.* Theſe are ſmall Circles drawn, or ſuppoſed to be drawn parallel to the Ecliptic, and ſerve to limit or determin the Latitude of any Celeſtial Object in the Circle of Longitude.

47. *Hour-Circles.* Theſe are Meridians, which paſs through every 15° of the Equinoctial, and divide the Surface of the Celeſtial Globe into twenty-four equal Parts, and conſequently, when reduced into Time, are juſt the Space of one Hour diſtant from each other.

48. The *Receſſion* or *Preceſſion* of the *Equinoxes.* This is a very ſlow Motion, which the Equinoctial Points (by ancient, and therefore by long Obſervation) are known to have from Eaſt to Weſt, directly contrary to the Order of the Signs themſelves, which is from Weſt to Eaſt, at the Quantity of one Degree in 72 Years, or of 50 Seconds in one Year; and by this retrograde Motion of the Equinoctial Points, and by that Means of the whole Ecliptic, they have receded or gone back from their Conſtellations; or (which is the ſame thing) the Conſtellations have preceded or gone before their Signs, in which they were at firſt (for originally they were both together) and therefore in about 25920 Years from the beginning of this Receſſion, as appears by multiplying 360 Degrees, which are the Number of Degrees in the Ecliptic, by 72 Years, the Equinoctial Points will make an entire Revolution; and this Receſſion of the ſaid Points, is the Reaſon why they, and all the reſt of the Signs, ſtand not in their own, but different Conſtellations. Thus the Aſteriſm or Conſtellation *Aries* ♈ is not now in its own Sign, but in the Sign *Taurus* ♉, ♉ in *Gemini* ♊, and ♊ in *Cancer* ♋, and ſo of the reſt quite round the Ecliptic, as they plainly appear upon the Celeſtial Globe.

Note, The Year 25920, from the beginning of the ſaid Receſſion, is called the Platonic Year; at the End of which, the Signs and their Conſtellations will be together again.

49. *Refraction.* This, in Aſtronomy, is the Difference, whether near or remote, between the true and apparent Altitudes of an Object; and this is occaſioned by the Atmoſphere, which ſurrounds the Earth, and which cauſes all Celeſtial Bodies to appear more elevated above the Horizon than they really are, and ſometimes to be brought to appear above the Horizon, when they are really below it.

50. *Twilight.* This is a Medium between Light and Darkneſs, and happens every Morning before the Sun riſes, and every Evening after he ſets. It is occaſioned by the Atmoſphere's refracting the Solar Rays, or bending them back again upon the Earth, when the Sun is below the Horizon; and, by Obſervation, is found to begin and end when the Sun is 18 Degrees below the Horizon.

51. The *Crepuſculum.* This is a Circle parallel to the Horizon, but at 18 Degrees below it, where Twilight begins on the Eaſtern Side before Sun-riſe, and ends on the Weſtern Side after Sun-ſet.

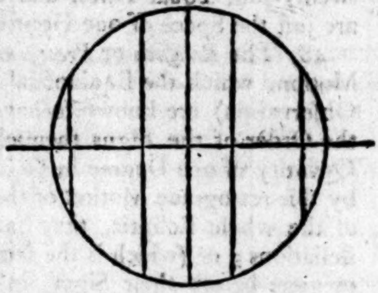
52. The *Atmoſphere.* This is a Quantity of Air ſurrounding the Earth; and riſes from it about 45 Miles perpendicular. It is the groſſeſt when neareſt the Earth, becauſe of its Weight and Preſſure; but the higher one aſcends, it is much thinner and finer. It is this which is the Occaſion of the Refraction and Twilight aforementioned, and in which the Clouds ſwim about, they being ſometimes higher, and ſometimes lower, according as they are lighter or heavier, or according to the rarity or denſity of the Atmoſphere.

Of the Poſitions of the Sphere *or* Globe.

The Poſitions of the Sphere are of three Sorts, *Right*, *Oblique*, and *Parallel.*

1. A *right Sphere* hath three Properties, *viz.*

(1.) Both Poles are in the Horizon.

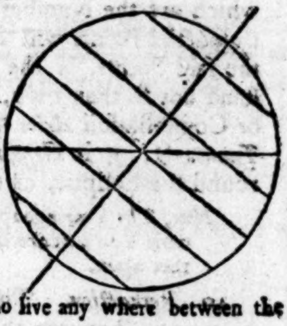


(2.) The Equator is half above the Horizon, and half under it: It alſo paſſes through the Zenith and Nadir; therefore the Days and Nights are always equal.

(3.) The Parallels of Declination are perpendicular to the Horizon, and therefore make right Angles with it. Hence the Amplitude is always equal to the Declination.

Note, The Inhabitants of *this Sphere* are thoſe only who live upon the Equator.

2. An *oblique Sphere* hath three Properties, *viz.*



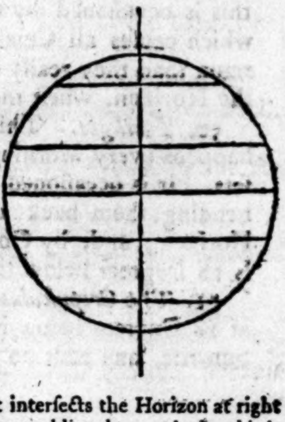
(1) One of the Poles is above the Horizon, and the other under it; the elevated Pole being juſt as much above the Horizon, as the other is beneath it.

(2.) The Equator is half above the Horizon, and half under it, as in the *right Sphere*; but the Days and Nights are unequal, except when the Sun is in the Equinoctial.

(3.) The Parallels of Declination cut the Horizon obliquely.

Note, The Inhabitants of *this Sphere* are all thoſe, who live any where between the Equator and the Poles.

3. A *parallel Sphere* hath alſo three Properties, *viz*



(1.) The Poles of the World are, one in the Zenith, and the other in the Nadir.

(2.) The Equator is in the Horizon, and therefore here are ſix Months Day, and ſix Months Night, Refraction excepted.

(3.) The Parallel Circles, or Parallels of Latitude or Declination, are all of them parallel to the Horizon.

Note 1. The Inhabitants of *this Sphere* (if there be any) are thoſe who live under the Poles.

2. All the ſeveral Poſitions of the Sphere, derive their Names from the ſeveral Poſitions of the Equinoctial with the Horizon: The firſt, becauſe it interſects the Horizon at right Angles; the ſecond, becauſe it interſects the Horizon obliquely; and the third, becauſe it is parallel to the Horizon.

Of the Inhabitants of the Earth, with reſpect to their Meridians, Parallels *and* Shadows.

I. *With reſpect to their Meridians and Parallels.*

Theſe are of three Sorts, *viz. Antiœci, Periœci,* and *Antipodes.*

1. *Of the* Antiœci.

Theſe are ſuch People, who by Situation live under the ſame Meridian, but oppoſite Parallels; *i. e.* If one Sort have 51° North Latitude, the other have 51° South Latitude; and theſe are oppoſite or *Antiœci* one to another.

Note 1. Theſe two differently ſituated People have the ſame Elevation of their Poles, but not the ſame Pole; thoſe in North Latitude having the North Pole elevated, and thoſe in South Latitude having the South Pole elevated to the ſame Degree.

2. They are equally diſtant from the Equator, but on different Sides, becauſe one is in North Latitude, and the other in South Latitude.

3. Their Noons and Midnights, and conſequently all the Hours of the Day and Night, are alike, becauſe they are under the ſame Meridian.

4. The Days of the one are equal to the Nights of the other, throughout the Year, becauſe of their oppoſite Latitudes, the Sun riſing and ſetting both ſooner and later with the one than with the other, except when he is in the Equinoctial, where he riſes and ſets to both alike.

5. The longeſt Day with one is the ſhorteſt Day with the other, and conſequently the longeſt Night with one, is the ſhorteſt Night with the other at the ſame time, becauſe their Meridian is the ſame, but their Parallels or Latitudes oppoſite.

6. The Seaſons of the Year are alſo contrary one to another, it being Winter, or the coldeſt Seaſon in one Latitude, when it is Summer, or the warmeſt Seaſon, in the other; except within the Torrid Zone: though, even there, they have their colder and warmer Seaſons, Rains, *&c.* though not ſtrictly called Winter.

7. Thoſe who live under the Equator have no *Antiœci.*

8. *Antiœci* is derived from *αντι contra,* and *οικος Domus,* to dwell in a contrary Parallel.

2. *Of the* Periœci.

Theſe likewiſe are two differently ſituated People, who live under the ſame Parallel of Latitude, whether North or South, but on oppoſite Meridians; *i. e.* if one Sort live in 51° North Latitude, the other live in the ſame Latitude alſo, but on the oppoſite Side of the Globe: And therefore ſuch People, by paſſing round about on the ſame Parallel, as the Greek Word *περι peri* imports, are *Periœci* one to another.

Note 1. Theſe two Sorts of People have the ſame Pole, and therefore, whether they dwell in North Latitude or South Latitude, have their Pole elevated to both alike, becauſe they live in the ſame Degree of the ſame Latitude, and conſequently have the other Pole equally depreſſed.

2. They are equally diſtant from the Equator, becauſe they are on the ſame Side of it, as well as in the ſame Latitude.

3. When it is Noon with the one, it is Midnight with the other; when Ten of the Clock in the Morning with the one, it is Ten at Night with the other, *&c.* becauſe of their being under oppoſite Meridians. Yet

4. Their Length of Days, and their Length of Nights are the ſame; and they agree exactly in the four Seaſons of the Year, becauſe their Latitude (as was obſerved before) is the ſame both in Kind and Degree.

5. Thoſe who live under the Poles have no *Periœci.*

6. *Periœci* is derived from *περι circum,* and *οικος Domus.*

3. *Of the* Antipodes.

Theſe alſo are two differently ſituated People, who live under oppoſite Meridians, and oppoſite Parallels; *i. e.* if one Sort live in 51° North Latitude, the other live in 51° South Latitude, but on the direct contrary Side of the Globe, and therefore are ***Antipodes***, or diametrically oppoſite one to another.

Note 1. Theſe two Sorts of People have, both of them, the ſame Elevation of their Poles, becauſe they live in the ſame Degree of Latitude, though one is North, and the other South; and therefore for the ſame Reaſon,

2. They are both equally diſtant from the Equator, though they live on direct contrary Sides of the Globe, and in oppoſite Hemiſpheres.
3. When it is Noon with the one, it is Midnight with the other; when Seven of the Clock in the Morning with the one, it is Seven at Night with the other, becauſe their Meridians are oppoſite.
4. The longeſt Day with the one is the ſhorteſt Day with the other, and conſequently the longeſt Night with the one is the ſhorteſt Night with the other, becauſe they live on oppoſite Sides of the Equator, and on oppoſite Meridians.
5. When it is Midſummer with the one, it is Midwinter with the other, becauſe of their oppoſite Latitudes and Meridians.
6. The Feet of the one are oppoſite to the Feet of the other, becauſe they are diametrically oppoſite; whence the Name αντιποδες *Antipodes*.
7. *Antipodes* is derived from αντι *contrà*, and πȣς *Pes*, i. e. *Pes contra Pedem*, or Feet to Feet.

II. *With regard to the Shadows which they make at Noon.*

In this Reſpect, the Inhabitants on the Globe of the Earth are of four Sorts, *viz. Aſcii*, *Amphiſcii*, *Heteroſcii*, and *Periſcii*.

1. *Of the* Aſcii.

Theſe have no Shadow at all, at Noon or Mid-day (the Word ασκια *aſkia* ſignifying without Shadow, or ſhadowleſs) becauſe the Sun is vertical at that time; but this is only twice in the Year, and within the Torrid Zone, when the Sun is departing from one Tropic to the other; and but once in the Year to thoſe Inhabitants who live under the Tropics.

Note, The *Aſcii* are not any particular Sort of People, becauſe all within the Torrid Zone are *Aſcii* in turn; that is, at ſuch time only when the Sun is vertical. Hence the Inhabitants of every Parallel, not only to every Degree, but every Minute alſo within the Torrid Zone, become *Aſcii* one after another.

2. *Of the* Amphiſcii.

Theſe People live within the Torrid Zone, and caſt their Noon-Shadow at different times both Ways, as the Greek Word αμφι *amphi* imports; *i. e.* ſometimes North, and ſometimes South, according as the Sun (moving from Tropic to Tropic) is to the Northward or Southward of them.

Note, In what Parallel ſoever of the *Amphiſcii* the Noon-Sun is vertical, thoſe Inhabitants, for that time, become *Aſcii*; and when the Noon-Sun is departed from their Zenith, they become *Amphiſcii* again.

3. *Of the* Heteroſcii.

Theſe Inhabitants are ſo named becauſe they caſt their Noon-Shadow always one Way. Yet theſe differ according to their Situation, that is, according to the Zones they live in, and therefore are of two Sorts, *viz.* one Sort living in the North Temperate Zone, having their Meridian-Sun due South, and therefore have their Noon-Shadow always full North. The other live in the South Temperate Zone, having their Meridian-Sun due North, and therefore have their Noon-Shadow full South.

Note 1. It is upon this Account, that the People inhabiting the two Temperate Zones are called *Heteroſcii*, becauſe they ſtand, as it were, oppoſed one to another, their Noon-Shadows being directly contrary, and not ſimply by themſelves, becauſe each one have their Noon-Shadow always one Way.

2. The Inhabitants, under either of the Tropics, are ſometimes *Aſcii* when the Sun is vertical to them, and *Heteroſcii* when the Sun is going to the oppoſite Tropic.

4. *Of the* Periſcii.

Theſe miſerable Inhabitants (if there be any) dwell within the two polar Circles, and therefore have their Shadows (when they have the Sun) turned quite round them once in 24 Hours, the Sun not ſetting with them for a time, from 24 Hours to ſix Months, according to their reſpective Latitudes.

Note 1. The Caſe is the ſame, whether it be within the North or South frigid Zone.

2. The Greek Word *περι peri* ſignifies round about, as was obſerved before, and σκια *ſkia* a Shadow: hence the Word *Periſcii* for ſuch Inhabitants as have their Shadows going quite round them.

A new

A new and complete
DESCRIPTION
Of the TERRESTRIAL and CELESTIAL
GLOBES,
With their ſeveral USES.

PART II.

Containing a compendious Syſtem of the Geography of the TERRESTRIAL GLOBE.

Of the Diviſion of the whole TERRAQUEOUS GLOBE.

THE whole terraqueous GLOBE is divided,

I. *Naturally* or ſimply into Land and Water, as at the Beginning, before the Creation of Man; and conſequently before any other Diviſions were impoſed; or as it is at preſent, excluſive of any particular Names of Countries, Parts or Diviſions.

II. *Politically*, as the whole Land ſtands divided into Empires, Kingdoms, Provinces, *&c.* and the whole Body of Water into Oceans, Seas, Lakes, Rivers, *&c.* bearing their ſeveral and reſpective Names, for the Benefit of Trade and Commerce.

I. The whole terraqueous Globe is naturally and ſimply divided into Land and Water.

1. The Land is divided into Continents, Peninſulas, Iſthmuſes, Iſlands, Promontories and Mountains.

2. The Water is divided into Oceans, Seas, Straits, Lakes, Bays or Gulfs, Rivers, *&c.* which I ſhall place in the following Manner, to ſhew the Learner what a Similitude there is between the ſeveral Parts of both Elements, and how naturally one ſeems to be productive of the other.

LAND.	WATER.
1. A *Continent* is a very large Tract of Land, comprehending ſeveral Kingdoms and States joined together, without any intire Separation of its Parts by Seas; as, *Europe*, *Aſia*, *Africa*, and *America*.	1. An *Ocean* is a very large and extenſive Collection of Water into one Body, without any intire Separation of its Parts by Land; as, the *Atlantic Ocean*, the *Southern Ocean*, the *Pacific Ocean*, the *Ethiopic Ocean*, &c.

LAND.	WATER.
2. A *Peninſula* is a Part of Land every where incloſed with Water, except a narrow Space or Neck, which joins the ſame to the Continent, like a Head to a Body; as, *Morea* is joined to *Greece*, *Crim Tartary* to *Little Tartary*, &c.	2. A *Sea* is a Part of Water every where incloſed with Land, except a narrow Space or Neck, which joins the ſame to the Ocean, like a Head to a Body; as, the *Baltick Sea*, the *Mediterranean Sea*, the *Euxine* or *Black Sea*, the *Adriatic Sea*, the *Red Sea*, &c.
3. An *Iſthmus* is a narrow Neck of Land, joining a Peninſula to its Continent; ſuch as that which joins *Crim Tartary* to *Little Tartary*, *Morea* to *Greece*, *Jutland* to *Denmark*, &c.	3. A *Strait* is a narrow Neck of Water, joining one Sea to another, or a Sea to the Ocean; ſuch as the *Sound* in *Denmark*, the *Straits* of *Gibraltar*, the *Straits of Caffa*, &c.
4. An *Iſland* is a Part of the Earth intirely ſurrounded by Water; ſuch as the *Britiſh Iſles*, *Ireland*, *Iceland*, &c.	4. A *Lake* is a Quantity of Water intirely ſurrounded by Land; ſuch as the *Lakes* of *Onega* and *Conſtance* in *Muſcovy*, *Ladoga* in *Sweden*, &c.
5. A *Promontory* is a Part of the Earth, which runs out a great Way into the Sea, and is about three Parts in four encompaſſed by it, the Extremity of which is called a *Cape*, *Headland*, or *Point*; ſuch as the *Cape of Good Hope*; the *Land's End* and *Lizard* in *England*, &c.	5. A *Bay* or *Gulf* is a Part of the Sea, which runs a great Way into the Land, and is about three Parts in four encompaſſed by it; ſuch as the *Bay of Biſcay* in *Spain*, the *Gulf of Lyons* in *France*, the *Perſian Gulf*, &c.
6. A *Mountain* or *Hill* is a large riſing Part of the Earth, overlooking the adjacent Country, and is the firſt that appears at a great Diſtance.	6. A *Wave* of the Sea is a huge riſing Part of the Water, overlooking the adjacent Parts below; which for the time of its Continuance may fitly be called a watery Mountain or Hill.
7. A *Hillock* or very little Hill, is a riſing of the Ground, occaſioned by the Ground being thrown up by Workmen for ſome particular Deſign.	7. A *Wave* of a River is a ſmall riſing of the Water, occaſioned by the Wind and Tide meeting together.
8. A Valley, or deep Part of the Earth, is a Space of Ground between two Hills.	8. That Space, which is between two Waves of the Sea, may not unfitly be called a watery Valley.

II. The whole terraqueous Globe is politically divided; the Land into Empires, Kingdoms, principal Cities, *&c.* and the Water into Oceans, Seas, Rivers, Lakes, *&c.* bearing their ſeveral and reſpective Names, for the Benefit of Trade and Commerce; which Names were uſed under the natural Diviſion, only for the better diſtinguiſhing thoſe ſeveral Parts which Nature had formed, and without which they could not ſo eaſily be underſtood.

1. *Of the* LAND.

The Land is divided into ſix large Continents, *viz. Europe*, *Aſia*, *Africa*, *America*, *Terra Arctica*, or *Terra Borealis*, *i. e.* the Northern Continent, and *Terra Antarctica*, or *Terra Auſtralis*, *i. e.* the Southern Continent, together with ſeveral other Places of later Diſcovery, called by ſome *South India*, not reckoned as any Part of the juſt mentioned Continents.

1. *Of* EUROPE.

The Continent of *Europe* is divided into

		Principal Cities.
Scandinavia	*Sweden*	*Stockholm.*
	Denmark	*Copenhagen.*
	Norway	*Bergen.*
Ruſſia or *Muſcovy*		*Moſcow.*
France		*Paris,*
Germany		*Vienna.*
Poland		*Warſaw.*
Spain		*Madrid.*
Portugal		*Liſbon.*
Italy		*Rome.*
Turkey in *Europe*		*Conſtantinople.*

To theſe may be added the following Iſlands, *viz.*

	Principal Cities.
Great Britain	*London*, *Edinburg.*
Ireland	*Dublin.*

Orkneys, *Shetland*, *Weſtern Iſlands*, *Man*, *Majorca*, *Minorca*, *Ivica*, *Corſica*, *Sardinia*, *Sicily*, *Candia*, *Rhodes*, *Cyprus*, a Knot of Iſlands in the *Archipelago*, or the *Archipelago* Iſlands, and the *Azores*.

2. *Of* ASIA.

The Continent of *Aſia* is divided into

	Chief Cities.
Tartary	*Thibet*, S. *Samarcand*, S. W. *Aſtracan*, W.
China	*Pekin*, N. *Nankin*, E.
India	*Agra*, *Dehli*, Middle.
Perſia	*Iſpahan*, W.
Turkey in *Aſia*	*Aleppo*, W.
Arabia	*Mecca*, W.

To which may be added the following Iſlands, *viz.*

Jopan Iſles, *Philippine* Iſles, *Ladrone* Iſles, *Molucca* Iſles, *Sonda* Iſles, *Ceilon*, and *Andaman* Iſles, *Chineſe* Iſles, *Borneo*, *Java*, *Sumatra*, and *Maldive* Iſles.

3. *Of* AFRICA.

The Continent of *Africa* is divided into

		Principal Cities.
1. *Barbary*	*Morocco*	*Morocco*
	Fez	*Fez.*
	Algier	*Algier.*
	Bildulgerid	*Caphoſa.*
	Tunis	*Tunis.*
	Tripoli	*Tripoli.*
	Zaara	Deſert.

		Principal Cities.
2. *Egypt*		*Cairo*, *Alexandria*.
3. *Nubia*		*Dangalla*.
4. *Abyſſinia*, or *Ethiopia Minor*		*Mina*.
5. *Nigritia*, or *Negroland*		*Tombut*, W.
6. *Guinea*	*Upper*, North of the Equator	*Benin*, E.
	Lower, South of the Equator	*St. Salvador*, W.
7. *Ethiopia*	*Upper*, or interior	*Magadoxa*.
	Lower, or exterior	*Monomotapa* Middle, *Moſambique*, E.

In *Monomotapa* is *Cafreria Orientalis*, *Eaſtern Cafreria*, and *Cafreria Occidentalis*, *Weſtern Cafreria*: The reſt of the Land conſiſts of *Hottentots* every where, in which are the Towns of *Penda*, *St. Catherine*, and that at *Promontorium Bonæ Spei*, or the *Cape of Good Hope*.

To *Africa* belong the following principal Iſles, *viz.*

	Chief Iſlands.
Madeira Iſles	*Madeira*.
Canary Iſles	*Canaria*.
Cape Verd Iſles	*St. Jago*.
Ethiopian Iſles	*St. Helena*.

Socotora Iſle, *Madagaſcar*, and ſeveral other ſmaller Iſlands on the N. E. and NE. of *Madagaſcar*.

4. *Of* AMERICA.

The Continent of *America* is divided into two Parts, *viz.*

1. *America Septentrionalis*, or *North America*, containing *California**, *Mexico Nova*, or *New Mexico*, *Old Mexico*, *Nova Hiſpania* or *New Spain*, *Louiſiana*, *Florida*, *Georgia*, *Carolina*, *Virginia*, *Maryland*, *Penſilvania*, *Jerſey*, *New England*, *Nova Scotia*, or *New Scotland*, *Terra de Laborador*, ſive *Nova Britannia*, or *New Britain*, *Canada*, *Venedotia*, or *New Wales*, and *Debenbartia*.

* *Note*, *California* is, upon ſome Globes and Maps, repreſented as an Iſland; but it is now known to be a Peninſula, and joined to the Continent at the North-Weſt End.

2. *America Meridionalis*, or *South America*, containing *Terra Firma*, or firm Land, *Peru*, *Chili*, *Paraguara*, or *Paraguay*, *Braſilia*, or *Braſil*, *Amazonia*, *Patagonia*, *Terra Magellanica*, or *Magellan's Land*, and *Guiana*.

To *America* belong the following principal Iſlands, *viz.*

Terra Nova, or *Newfoundland*, *Bermudas*, or Summer Iſles, *Bahama* Iſles, great and little (ſo diſtinguiſhed upon Mr. *Price*'s Globes) the great *Antilles*, which are *Cuba*, *Hiſpaniola*, *Jamaica*, and *Porto Rico*; the *Caribbee* or leſſer *Antilles*, which are *St. Martin*, *Montſerrat*, *Guardeloupe*, *Martinico*, *Barbados*, *Granada*, and *Tobago*, *Terra del Fuego*, or Land of Fires, and *Gallipago* Iſles, on the Weſt of *Terra firma*; *Cape Briton*, *St. John's*, *Falkland* Iſlands, and ſundry others on the Eaſtern Coaſt; and *St. Juan Fernandes*.

5. *Terra Arctica*, or the *Arctic Land*.

This great Tract of Land, called alſo *Terra Borealis*, or Northern Land, lies altogether within the North Polar or Arctic Circle, and is very little known to us; and hence it is alſo called *Terra incognita*, or unknown Land, becauſe the continual ſevere Froſt, which renders the whole extremely cold, has forbid, hitherto, any Attempt towards making new Diſcoveries.

6. *Terra Antarctica*, or the *Antarctic Land*.

This is another only ſuppoſed great Tract of Land, imagined to lie within the South Polar or Antarctic Circle; and as no Part of it is known to us (no Man ever having been in that Part of the World by Choice, or if forced there by tempeſtuous Weather, never lived to bring any Account of it, but periſhed) it is therefore only imaginary, and like the *Arctic Land*, called *Terra incognita*, or *unknown Land*; its remoteneſs, Want of Trade, and the common Neceſſaries of Life that Way, and extreme cold, giving no Invitation to Mariners to try the Experiment.

Note, Notwithſtanding that Mention is made of *Terra Arctica* and *Terra Antarctica*, yet, becauſe thoſe two Parts of the World are only imaginary Tracts of Land; or (if there ſhould be any) are wholly unknown, and, conſequently, cannot be delineated; therefore it is uſual with Geographers, on their Maps and Globes, to repreſent Water inſtead thereof.

7. SOUTH INDIA.

Under this Title are comprehended ſeveral Places not known to the Ancients, but have been diſcovered within two or three hundred Years laſt. They are

1. *New Guinea*, diſcovered by one *Saavedra*, a *Spaniard*, in 1529, a little South of the Equator, and 135° E. from *London*.
2. *New Britain* was diſcovered by *Dampier* in 1700, about 40 Miles Eaſtward of *New Guinea*.
3. *Spirito Santo*, or *Holy Spirit*, was diſcovered near the End of the ſixteenth Century, by *Fernando Quiros*, a *Spaniard*, between 10° and 20° of South Latitude, and 150° E. of *London*.
4. *Nova Hollandia*, or *New Holland*, was diſcovered by ſome *Hollanders* firſt in 1644. It lies under the Tropic of ♑, 130° E. of *London*.
5. *Dieman's Land*, diſcovered by *Abel Taſman*, in 1642; Lat. 42° S. Long. 142° E. of *London*.
6. *Nova Zelandia*, or *New Zeland*, was diſcovered by Capt. *Taſman* in 1642; Lat. 40° S. Long. 170° E. of *London*.
7. *Bovet's Land* was diſcovered by Capt. *Bovet*, a *Frenchman*, in 1739; Lat. 54° S. Long. 12° E.

2. *Of the* WATER.

The Water is divided into Oceans, Seas, Straits, Lakes, Bays or Gulfs, and Rivers

1. *Of the* OCEANS.

1. *Oceanus Atlanticus* ſive *Occidentalis*, The *Atlantic* or *Weſtern Ocean*; (ſo called, in all probability, from its being Weſtward of *Europe*) great Part of which lies between *Europe*, *Africa*, and *America*, and ſtretches itſelf to the Northward of *Europe*, *Aſia*, and *America*, towards the North Pole.

Note, It is called *Weſtern*, in all probability, becauſe it is on the Weſt Side of *Europe*, that being the beſt peopled Part of the World, tho' leaſt of the four Quarters.

The *Ethiopic*, or *Ethiopian Ocean*, lies between the South Part of *Africa* and the South Part of *America*, and ſtretches itſelf exceeding much towards the South Pole.

3. *Oceanus magnus*, or the *great Ocean*, called the *South Sea*, which is extenſively large on both Sides of the Equator, and lies between all *America*, all *Aſia*, and *Nova Hollandia*

Note 1. In this vaſt Ocean the Winds have a Conformity with thoſe in the *Atlantic* and *Ethiopic*, with ſo much Conſtancy alſo, that they ſeldom uſe to attend the Sails; and it is rare to fail of croſſing it in the Space of ten Weeks, which is about 130 Miles a Day.

2. The ſhort *Lines* and *Arrows* interſperſed between the Latitudes of 30° *North* and *South*, in *both Hemiſpheres*, denote the Limits and Courſe of thoſe perpetual Winds called Trade-Winds; the Dart-End pointing whither it blows, the *Arrows* flying before the Wind.

4. *Oceanus Orientalis*, the *Eaſtern Ocean*, lies between the Eaſtern Coaſts of *Africa*, and the Southern of *Aſia*.

Note, It is called *Eaſtern*, in all probability, becauſe it is Eaſtward of *Europe*.

5. *Oceanus Pacificus*, the *Pacific Ocean*, which lies on the Weſt of *South America*, and is Part of the *Oceanus magnus*.

2. *Of the* SEAS.

Thoſe in *Europe* are,

1. *Mare Mediterranean*, or the *Mediterranean Sea*, between *Europe* and *Africa*.

2. *Sinus Venetus*, *vel Mare Adriaticum*, the *Gulf of Venice*, or *Adriatic Sea*, between *Italy*, *Turkey*, and *Greece*.

3. The *Pontus Euxinus*, or *Black Sea*, in *Turkey*.

4. *Mare Album*, the *White Sea*, in the N. W. Parts of *Muſcovy*.

5. *Mare Balticum*, or the *Baltic Sea*, between *Sweden*, *Denmark* and *Poland*.

2. The Seas in *Aſia* are,

1. *Mare Caſpium*, the *Caſpian Sea*, on the Eaſt of *Pontus Euxinus*, and North of *Perſia*.

2. *Mare Glaciale*, the *Icy Sea*, in the Arctic Circle.

3. *Mare Lenæ*, the Sea of *Len*, ſo called becouſe it waſhes the Coaſts of the Country of *Len*, in the N. E. of *Tartary*.

4. *Mare Orientale*, the *Eaſtern Sea*, between *Tartary*, *Yedſo*, and the *Japan* Iſles.

5. *Sinus Bengalenſis*, vel *Mare Bengalenſe*, the Bay or Sea of *Bengal*, between the Eaſt and Weſt Part of *India*.

6. *Mare Arabicum*, the *Arabic Sea*, between *Arabia* and *India*.

7. *Mare Indicum*, the *Indian Sea*, South of *Mare Arabicum* and *Sinus Bengalenſis*.

Note, In theſe Seas are marked the *Monſoons*, or ſhifting *Trade-Winds*, which blow ſix Months one Way, and ſix Months the direct contrary; the Motion of theſe *Winds* being marked by *Darts*, in their natural Poſition of flying thro' the Air.

8. *Sinus Perſicus*, vel *Mare Perſicum*, the *Perſian Gulf* or *Sea*, between *Perſia* and *Arabia*.

3. The Seas in *Africa* are,

1. *Mare Rubrum*, the *Red Sea*, between *Africa* and *Aſia*.

2. *Mare Moſambicæ*, the *Moſambic Sea*, between *Africa* and *Madagoſcar*.

3. *Aſperum Mare*, the *Rough Sea*, North of *Madagaſcar*.

4. The Seas in *America* are,

1. *Sinus Mexicanus*, vel *Mare Mexicanum*, the Bay, Gulf, or Sea of *Mexico*.
2. *Sinus Campeachiensis*, vel *Mare Campeachiense*, the Bay or Sea of *Campeachy*, South of *Sinus Mexicanus*.
3. *Sinus* vel *Mare Honduræ*, the Bay or Sea of *Honduras*, S. W. of *Sinus Campeachiensis*.
4. *Panama Sinus*, the Bay of *Panama*, N. W. of *Terra Firma*, in the *Oceanus magnus*.
5. *Sinus Californiæ*, the Gulf of *California*, between *California* and *North America*.
6. *Sinus Hudsoni*, *Hudson's Bay*, in the Northern Part of *North America*.
7. *Hudsoni Fretum*, *Hudson's Straits*, East of *Sinus Hudsoni*.
8. *Sinus Baffini*, *Baffin's Bay*, N. of *Sinus Hudsoni*.

A new and complete
DESCRIPTION
Of the TERRESTRIAL and CELESTIAL
GLOBES,
With their ſeveral USES,

PART III.

Containing the Uſe of the Terreſtrial Globe, exemplified in 68 Problems, with very eaſy Directions for working them.

PROBLEM I.

THE Latitude of a Place being given to ſet the Globe to it, commonly called Rectifying the Globe.

Given *London* in 51° 32′ North Latitude ;
Required the Globe to be rectified for that Place.

1. Set the Globe upon a true Plane.
2. Raiſe the North Pole till the given Degree of Latitude on the Brazen Meridian under the elevated Pole, juſt cut the Horizon.
3. Bring *London* to the Meridian, and fix the Globe by putting a Quill between the Globe and the Meridian.
4. Fix the Quadrant of Altitude in the Zenith of the Meridian, that is, directly over the Place given.
5. Place the Globe ſo that the Poles may ſtand due North and South ; which may be done by a Compaſs laid on the Horizon, or at the bottom of the Globe: So is the Globe and the World alike ſituated to an Obſerver at *London*, and the Globe is rectified for that Place.

Note. If the *Globe* be duly placed within its *Horizon*, ſuch *Horizon* will cut the braſs Meridian in 38° 28′ on the oppoſite Side of the *Globe*, which is the Complement of the given *Latitude*.

Again,

Given the Cape of Good Hope in 34° 15′ South Latitude ;
Required the Globe to be rectified for that Place.

1. As before.
2. Raiſe the South Pole till the given Degree of Latitude on the Brazen Meridian under the elevated Pole, cuts the Horizon.
3. Bring the Cape to the Meridian, &c.
4. Fix the Quadrant of Altitude over the Cape.
5. As before.

PROBLEM II.

The Day of the Month being given, to find the Sun's Place in the Ecliptic, and to rectify the Globe for that Day.

Given *May* 12, N. S. at *London* in Lat. 51° 32′ N.
Required the Sun's Place, and the Globe to be rectified for that Day.

1. Look for the Day of the Month in the Calendar for N. S. on the Horizon, and directly againſt it, ſtands 21° 37′ of ♉ *Taurus*.
2. Find the ſame Sign and Degree in the Ecliptic on the Globe, and you have your Deſire, that is, the Sun's Place.
3. Bring the Sun's Place to the Meridian, and fix the Globe.
4. Turn the Index of the horary Circle to the uppermoſt 12, which repreſents Noon or Mid-day.
5. Raiſe the Pole to the Latitude of the Place given.
6. Fix the Quadrant of Altitude to the Zenith, or Latitude of the Place, and the Globe is rectified for the given Day.

PROBLEM III.

The Sun's Place being given, to find the Day of the Month.

Given the Sun's Place in 19° 30′ of ♈ *Aries*.
Required the Day of the Month.

Look for the Sun's Place in the innermoſt Circle on the Horizon, and right againſt it, is *April* 9th.

PROBLEM IV.

A Place being given, to find the Latitude and Longitude of the ſame.

Given *London*
Required its Latitude and Longitude.

1. Turn the Globe, till *London* comes under the Eaſtern ſide of the brazen Meridian, and fix it there.
2. Right over *London* on the ſaid Meridian is 51° 32′ for the Latitude.
3. Obſerve what Degree of the Equator is juſt under the Eaſtern ſide of the Meridian, for that is the Degree of Longitude, which for *London* is 0° 0′, becauſe the firſt Meridian, for honour of the Place is ſituated there.

PROBLEM V.

Two Places being given to find their Difference of Latitude.

Note, The Difference of Latitude between any two Places is equal to an Arch of the Meridian intercepted between their Parallels; or it is the neareſt Diſtance between the Parallels paſſing thro' the two given Places, whether they lie under the ſame or different Meridians.

I. In the ſame Latitude.

Given *London* and *Rome*, both in North Latitude.
Required the Difference of Latitude between them.

1. Bring each Place to the Meridian, and mark its Latitude, as in Prob. 4. viz. *London* 51° 32′, and *Rome* 41° 51′.

2. Count the Degrees between the Interſections, and they will be the Difference of Latitude, *viz.* 9° 41′.

Or thus,

When the Latitudes are both North, or both South, ſubtract the leſſer Latitude from the greater; the Remainder is the Difference, as above, and in the following Example.

Given *Buenos Ayres* and *St. Helena*, both in South Latitude;
Required the Difference of Latitude between them.

Anſwer, 18° 35′

II. In different Latitudes.

Given *Amſterdam* in North Latitude, and *Cape Horn*, in South Lat.
Required the Difference of Latitude between them.

1. And 2. as before, ſo will the Anſwer be 107° 44′.

Or thus,

When one Latitude is North, and the other South, add their Latitudes together, and the Sum is the Difference of Latitude between them.

PROBLEM VI.

Two Places being given, to find the Difference of Longitude between them.

Note, The Difference of Longitude between any two Places, is equal to an Arch of the Equator intercepted between the Meridians of thoſe Places; or it is the Diſtance of their Meridians meaſured on the Equator, whether thoſe Places are ſituated on the ſame or different Parallels.

I. In the ſame Longitude.

Given *Rome* and *Fort St. George* in the Bay of *Bengal*, both in Eaſt Longitude;
Required the Difference of Longitude between them.

1. Bring each Place to the Meridian, and obſerve where they cut the Equator, which mark with Chalk, *viz.* *Rome* 12° 45′, and *Fort St. George* 81° 30′.

2. Obſerve how many Degrees there are on the Equator, between the two Interſections, and they will be the Difference of Longitude required, *viz.* 68° 45′.

Or thus,

If the Longitudes are both Eaſt, or both Weſt, ſubtract the leſſer Longitude from the greater; the Remainder is the Difference, as in the foregoing and following Example.

Given *Breſt* in *France*, and *Boſton* in *New England*, both in Weſt Longitude.
Required the Difference of Longitude between them.

Anſwer, 67° 30′.

II. In

II. In different Longitudes.

Given *Alexandria* in Eaſt Longitude, and *Dublin* in Weſt Longitude; Required the Difference of Longitude between them.

Anſwer, 37° 16′.

Or thus,

If the Longitudes are one Eaſt, and the other Weſt, then add the Longitudes together, and the Sum will be the Difference of Longitude, if it exceed not 180°; but, if it does, ſubtract that Sum from 360°, and the Remainder is the Difference of Longitude.

PROBLEM VII.

The Latitude of any Place being given to find all thoſe Places, which have the ſame Latitude.

Given *London* in Latitude 51° 32′ North.
Required all thoſe Places, which have the ſame Latitude.

1. Bring *London* to the Meridian.
2. Mark its Latitude on the Meridian, with a Piece of Chalk, for Diſtinction's ſake.
3. Turn the Globe quite round, and obſerve, what Places paſs under the ſaid Mark, for they have all the ſame Latitude, with the given Place. Or,
4. Hold a Piece of pointed Chalk againſt the Latitude given, in ſuch a Manner, that by turning the Globe round, it may deſcribe a Circle, which Circle will paſs over all thoſe Places, having the ſame Latitude, with the given Place.

PROBLEM VIII.

The Longitude of a Place being given to find all thoſe Places, which have the ſame Longitude.

Given *Copenhagen* in *Denmark*;
Required all thoſe Places of the ſame Longitude.

1. Bring *Copenhagen* to the Meridian, and fix the Globe there.
2. All Places lying under the ſame Semi-circle of the Meridian, are of the ſame Longitude, with *Copenhagen*.

PROBLEM IX.

The Latitude and Longitude of a Place being given to find that Place.

Given a certain Place, in Lat. 41° 54′ N. Long. 13° 30′ E.
Required that Place.

1. Look on the Equator, for the Longitude, and bring it to the Meridian.
2. Fix the Globe in that Poſition.
3. Look on the Meridian, for the Latitude, and directly under it is *Rome*, the Place required.

PROBLEM X.

Any Place being given, to move the Globe, ſo as, that the wooden Horizon ſhall be the true Horizon of that Place.

Given *Paris*, in Lat. 48° 50′ N.
Required the Horizon of that Place.

1. Rectify the Globe, according to the Latitude of *Paris*.
2. Bring *Paris* to the Meridian, and fix the Globe there.
3. Then is the Horizon of the Globe, the true rational Horizon of the given Place.

PROBLEM XI.

The Globe being turned about, and either of the Poles elevated at Pleaſure, this random Poſition being given, to find what Place ſhall have the wooden Horizon, for its true Horizon.

Given the Globe in a random Poſition;
Required the Place, whoſe true Horizon ſhall be the wooden one.

1. Turn the Globe any way at Pleaſure.
2. Elevate either of the Poles, at Pleaſure; and both of them, blindfold, if it be agreeable.
3. Look under the elevated Pole, and obſerve, what Degree of the Meridian is cut by the Horizon, which is the Latitude of the deſired Place.
4. Look for the ſame Latitude, in the uppermoſt Part of the Meridian, and right under it, is the Place, whoſe true Horizon is the ſame, with the Horizon of the Globe.

PROBLEM XII.

A Place being given in the torrid Zone, to find thoſe Days, in which the Sun ſhall be vertical to the ſame at Noon.

Given *Borneo* in the Iſland *Borneo*;
Required thoſe Days, in which the Sun will be vertical there.

1. Bring the given Place to the Meridian, and mark its Latitude thereon with a Piece of Chalk, or Patch.
2. Turn the Globe about, and obſerve the Signs and Degrees in the Ecliptic, paſſing under the ſame Mark, which are ♍ 18° and ♈ 12°.
3. Look on the Horizon, and againſt ♍ 18° is *Sept.* 11*th*, and alſo againſt ♈ 12° is *April* 2*d*, on which two Days, the Sun will be vertical, at *Borneo*, at 12 o'Clock.

Note 1. The Sun is never *vertical* in any Place, but in the torrid Zone: and never there, but at Noon, *i. e.* In what Place ſoever, the Sun is *vertical*, it is Mid-day or Noon, at that Place.

2. The Sun is *vertical* in every Place in the torrid Zone, twice a Year, except at the firſt Scruple of ♋, and alſo of ♑, in which Place it is *vertical*, but once.

PROBLEM XIII.

The Day of the Month being given, to find in what Places, the Sun will be vertical, at their Noon, on that Day.

Given, *June* 24*th*.
Required all thoſe Places, where the Sun will be *vertical* on that Day

1. Find the Sun's Place in the Ecliptic, for the given Day, *viz.* 3° 17′ ♋.
2. Mark it, and bring it to the Meridian.

3. Obſerve what Degree it paſſes under; and mark it alſo with Chalk, or a Patch.

4. Turn the Globe quite round, and all Places that paſs under the ſaid Mark, will have the Sun vertical, or in the Zenith, that Day, at the Noon of each Place.

PROBLEM XIV.

The Latitude of a Place, and Day of the Month being given, to find the Sun's Meridional Altitude, for that Day.

Given *London*, in Lat. 51° 32′ N. and *Aug.* 26*th*.
Required the Sun's Meridional Altitude.

1. Rectify the Globe, for the given Latitude.
2. Find the Sun's Place in the Ecliptic, for the given Day, by *Prob.* II.
3. Mark that Place on the Globe, and bring it to the Meridian.
4. Obſerve how many Degrees on the Meridian are intercepted, between the Sun's Place, and the Horizon; for they are the Sun's Meridional Altitude, on the Day and Place given, *viz.* 48° 51′.

ARITHMETICALLY.

° ′
90 0
51 32 = *the Lat. of* London.
38 28 = *the Height of the Equator, above the Horizon.*
+ 10 23 = *the Sun's Declination North*; *add*
48 51 = *the Sun's Meridional Altitude.*

Again:

Given *London*, in Lat. 51° 32′ N. and *Jan.* 27*th*.
Required the Sun's Meridional Altitude.

° ′
90 0
51 32 = *the Lat. of* London.
38 28 = *the Height of the Equator, above the Horizon.*
— 18 24 = *the Sun's Declination, South: ſubtract*,
20 4 = *the Sun's Meridional Altitude.*

Thus in any North Latitude, by adding the Sun's Declination North, to the Height of the Equator; or ſubtracting the Sun's Declination South from it, the Sun's Meridional Altitude for any Day, is eaſily obtained without the Globe.

Likewiſe in any South Latitnde, by adding the Sun's Declination South, to the Height of the Equator, or ſubtracting the Sun's Declination North from it, the Sun's Meridional Altitude is obtained.

PROBLEM XV.

The Latitude of a Place, and the Sun's Meridional Height being given, to find the Day of the Month.

Given *London*, in Lat. 51° 32′ N. and the Sun's Meridional Altitude 48° 51′.

Required the Day of the Month.

1. Rectify the Globe, for the given Latitude.

2. Reckon, upon the Meridian, from the South-ſide of the Horizon, the given Number of Degrees, and where the Reckoning ends, there make a Mark with Chalk, or a Patch.

3. Conſider, whether the Sun has paſſed the ſolſticial Colure, that is, the firſt Scruple of ♋ or not, and accordingly, you muſt bring the Ecliptic to coincide with the Mark, made on the Meridian: In the preſent Caſe, the Sun is ſuppoſed to have paſſed the Tropic of ♋, and therefore the Mark will fall on 3° 6′ of ♍.

4. Look on the Horizon, for 3° 6′ of ♍, and againſt it, you will have *Aug. 26th.*

PROBLEM XVI.

The Hour of the Day in any Place being given, to find what Hour it is in any other Part of the World.

Given Noon, at *London*;

Required the Hour of the Day, at *Port Royal* in *Jamaica*.

1. Bring *London* to the Meridian, and fix the Globe.

2. Set the Index of the Hour-circle to the upper 12, which is the Hour of the Day.

3. Bring *Port Royal* to the Meridian.

4. Then will the Index point to three Quarters after Six, on the eaſtern Semi-circle, or in the Morning, which is the Hour of the Day deſired at that Place.

PROBLEM XVII.

The Place where a Perſon is in, Month, Day, and Hour of the Day, at that Place being given; to find in what particular Place the Sun will be vertical, at that Time.

h. m.
Given *London*, *June 24th*, 8 52. A. M.

Required the Place, where the Sun will be vertical, at that Time.

1. Find the Sun's Place in the Ecliptic, for the Day given, by *Prob.* II. *viz.* 2° 47′ of ♋.

2. Mark it, and bring it to the Meridian.

3. Obſerve what Degree it paſſes under, and mark that alſo.

4. Bring *London* to the Meridian, and fix the Globe.

h. m.
5. Set the Index of the horary Circle to the given Hour, *viz.* 8 52 on the eaſtern Side of the Circle, becauſe it is Morning.

6. Turn the Globe, till the Index comes to the uppermoſt 12.

7. Then look, what Place on the Globe lies directly under the Mark in the Meridian, for that is the Place, where the Sun is vertical, at the given Time, *viz. Cariathaim*, or very near it.

PROBLEM XVIII.

The Day of the Month, and Latitude of a Place being given, to find the Length of the Day and Night, at that Place.

Given *Sept.* 14 N. S. at *London,* in Lat. 51° 32′ N.
Required the Length of that Day and Night.

1. Raiſe the Pole to the Latitude of the Place given.
2. Find the Sun's Place in the Ecliptic, for the given Day, and mark it.
3. Bring the Sun's Place to the Eaſt-ſide of the Horizon, and fix the Globe.
4. Set the Index to 12 at Noon.
5. Turn the Globe about, till the Sun's Place touch the Weſt Side of the Horizon.
6. Look on the Hour Circle, and count the Hours, from Noon to the Hour where the Index now ſtands; the ſame is the Length of the given Day, *viz.* 12hrs. 2qrs.
7. The Complement is the Length of the Night, *viz.* 11hrs. 2qrs.

PROBLEM XIX.

A Place being given, to find the *Antiœci, Periœci,* and *Antipodes* of that Place.

Given *London,* in Lat. 51° 32′ N.
Required the *Antiœci, Periœci,* and *Antipodes* of that Place.

1. Bring *London* to the Meridian, and fix the Globe.
2. Look on the Meridian for the like Latitude, South; whatever Place lies in that Latitude, and under the ſame Meridian is the *Antiœci* of *London.*

Note, This happens to be a Point in the Southern Part of the *Ethiopic Ocean,* where there are no Inhabitants.

3. Set the Index of the horary Circle to 12 at Noon.
4. Turn the Globe about, till the Index points to 12 at Night.
5. The Place then lying directly under the given Latitude, is the *Periœci* of *London.*

Note, This alſo happens to be a Point in the Northern Part of *Oceanus Magnus,* where there are no Inhabitants.

6. Keep the Globe in the ſame Poſition, and obſerve, what Place lies directly under the given Degrees, in South Latitude, for that is *Antipodes* of, or diametrically oppoſite to *London.*

Note, This likewiſe happens to be a Point in the Southern Part of *Oceanus Magnus,* where there are no Inhabitants.

PROBLEM XX.

The Latitude of a Place, Month, Day and Hour being given, to find all thoſe Places in which the Sun is in its Meridian, at that Time.

Given *London,* in Lat. 51° 32′ N. *May 14th,* 1 P.M.
Required all thoſe Places, in whoſe Meridian the Sun will be at that Time.

1. Elevate the Globe to the given Latitude.
2. Bring the given Place to the Meridian.
3. Set the Index to the Hour of the Day given.

4. Turn the Globe, till the Index points at 12 at Noon.

5. Fix the Globe in that Situation.

6. Obſerve, what Places, lie under the Eaſtern-ſide of the Meridian, in the upper Hemiſphere, which are the Places deſired.

Note, If the Sun's Place for the given Day be marked upon the Meridian, the Pupil may be informed in what Places the Sun is then full North, full South, and vertical.

PROBLEM XXI.

Any particular Place, and its Latitude, with the Hour of the Day being given, to know when the *Grand Turk*, prays to Mahomet.

Note, The *Turks* always go to Prayer, at 12 o'Clock.

Given *London*, in Lat. 51° 32′ N. and 9 *hrs*. 30 *min*. A. M.
Required when the *Grand Turk*, will go to Prayer.

1. By Problem 16*th*, find the Hour at *Conſtantinople* for the given Time; which is 11 *hrs*. 30 *min*. nearly, A. M.

2. Hence it appears, that about half an Hour, the *Grand Turk* will pray to Mahomet.

In General.

1. By Problem 16*th*, find the Hour of the Day at *Conſtantinople*, aforeſaid (that being the *Grand Turk's* chief Place of Reſidence) at the Time you make your Obſervation.

2. If the Sun has paſt the Meridian, at *Conſtantinople*, the Time of going to Prayer is over.

3. If the Sun has not yet come to the Meridian of that Place, then the Time of going to Prayer is to come; both which are pointed out by the Index.

PROBLEM XXII.

The Latitude of a Place being given, to find the Hour of the Day, at any Time, when the Sun ſhines.

Given *London*, in Lat. 51° 32′ N.
Required the Hour of the Day.

1. Divide the Equator into 24 equal Parts, which may readily be done by bringing either of the firſt Points of ♈ or ♎ to the Meridian, and placing the Index of the horary Circle, at 12; then by turning the Globe gradually, till the Index points exactly at the reſpective Hours, quite round, make Marks on the Equator, either with Chalk, or a black Lead Pencil.

2. At the firſt Points of ♈ and ♎, place the Number VI.

3. Bring either of them to the brazen Meridian, then will one be in the upper, and the other in the lower *Hemiſphere*.

4. In the weſtern *Hemiſphere*, proceeding Weſterly, ſet down VII, VIII, IX, X, XI, XII, I, II, III, IV, V, and ſo on, quite round VII, VIII, IX, X, XI, XII, I, II, III, IV, V.

5. Elevate the Pole to the Latitude of the Place.

6. Bring the Point ♈ to the Meridian, and fix the Globe in that Poſition.

7. Place the Globe, due North and South, by a Meridian Line, or a good Compaſs, duly allowing for the Variation at the Place propoſed.

8. Obſerve the Line of Partition, between Sun-ſhine and Shade, on the weſtern Side of it, if it be Morning, and on the eaſtern Side of it, if be Afternoon; the ſame will ſhew the Hour on the Equator.

Or, more practically, thus.

1. Elevate the Globe, according to the Latitude of the given Place.
2. Place the Globe, due North and South, as before.
3. The horary Circle then becomes a polar Sundial, and the lengthened Axis of the Globe, in its Center, is the Gnomon or Style, the Shadow of which will ſhew the Hour of the Day.

Note, As the *Shadow* will be broad, becauſe that Part of the Axis is thick, it muſt be the middle of the *Shadow*, that will ſhew the true Hour.

PROBLEM XXIII.

The Latitude of a Place, and Day of the Month being given, to find the Hour of the Day.

Given *London*, in Lat. 51° 32′ N. and *May* 14*th*;
Required the Hour of the Day.

1. Elevate the Pole for the given Latitude.
2. Fix the Globe, North and South, by a Compaſs, Allowance being made for the Variation.
3. Find the Sun's Place in the Ecliptic, by *Prob.* 2, for the given Day; and mark it on the Globe.
4. Fix a ſmall Needle, or Pin without the Head, perpendicularly in the Sun's Place.
5. Bring the ſame to the Meridian.
6. Set the Index at Noon.
7. Turn the Globe about, till the Needle or Pin points to the Sun, and makes no Shadow, and fix it there.
8. The Index will then ſhew the Hour, in the Morning before XII, or in the Afternoon after XII.

Note, If the Hour required is in the Afternoon, the Needle or Pin muſt be taken out, till the Sun's Place is paſſed to the Weſtward of the Meridian, and then fix the Pin or Needle again.

PROBLEM XXIV.

The Latitude of a Place, Day of the Month, and Sun's Altitude being given, to find the Hour of the Day.

Given *London*, in Lat. 51° 32′ N. *Sept.* 14*th*, Sun's Altitude 12°.
Required the Hour of the Day.

1. Rectify the Globe for the given Latitude.
2. Find the Sun's Place in the Ecliptic, by *Prob.* 2, and mark it on the Globe.
3. Bring it to the Meridian, and fix the Globe.
4. Place the Index at Noon.
5. Fix the Quadrant of Altitude in the Zenith.
6. Take the Sun's Altitude, by a Quadrant, (if need be) which ſuppoſe 12° as above.
7. Mark that Altitude on the Quadrant of Altitude, with a Piece of Chalk.

8. Move the Globe, and the Quadrant of Altitude together, ſo as that the Sun's Place in the Ecliptic, and his Altitude marked on the Quadrant meet in one Point.

> *Note*, If it be Morning, the Meeting muſt be on the eaſtern Side of the Meridian, but if in the Afternoon, the Meeting muſt be on the weſtern Side.

9. The Index will ſhew the Hour deſired, *viz.* 7 A. M. or 5 P. M.

PROBLEM XXV.

The Latitude of a Place, Day of the Month, and Hour of the Day being given, to find the Sun's Altitude.

Given *London* in Lat. 51° 32′ N. *Sept.* 14*th*, at 7 A. M.
Required the Sun's Altitude, at that Hour.

1. Rectify the Globe for the given Latitude.
2. Find the Sun's Place in the Ecliptic for the given Day, and mark it on the Globe.
3. Bring the Sun's Place to the Meridian, and fix the Globe.
4. Put the Index to Noon.
5. Fix the Quadrant of Altitude in the Zenith.
6. Turn the Globe, till the Index points at the given Hour, and fix it again.
7. Turn the Quadrant, till the graduated Edge coincide with the Sun's Place, and the Sun's Altitude is ſhewn on the Quadrant, *viz.* 12° 30′.

PROBLEM XXVI.

The Latitude of a Place, Day of the Month, and true bearing of the Sun being given, to find the Hour of the Day.

Given *London*, in Lat. 51° 32′ N. *Aug.* 23*d.* the Sun bearing Weſt.
Required the Hour of the Day.

1. Rectify the Globe to the given Latitude.
2. Find the Sun's Place for the given Day, and mark it on the Globe.
3. Bring the Sun's Place to the Meridian, and fix the Globe.
4. Set the Index at Noon.
5. Fix the Quadrant of Altitude, in the Zenith of the Place.
6. By the Mariner's Compaſs (Variation allow'd) obſerve the true bearing, which ſuppoſe to be Weſt.
7. Bring the Quadrant of Altitude to the obſerved Point of the Compaſs upon the Horizon.
8. Move the Globe, till the Sun's Place coincide with the Quadrant, and fix it.
9. Then will the Index ſhew the Hour of the Afternoon in that Day, *viz.* 5 *hrs.* 30 *min.*

PROBLEM XXVII.

To find the Meridian Line of any Place, at any Time, when the Sun-ſhines.

Given *London*, in Lat. 51° 32′ N. *May* 14*th*.
Required the Meridian Line for that Place.

> *Note*, The Meridian Line, is a Line, that runs directly North and South, in any Place upon a true Plane.

1. Elevate the Globe to the given Latitude.

2. Take the Altitude of the Sun, by a Quadrant, and mark it on the Quadrant of Altitude.

3. Set up a large Pin, or Piece of Wire, perpendicular upon a true Plane, or Piece of Paper.

4. Draw a ſtraight Line, at Pleaſure, in, or parallel to the Shadow of the Pin or Wire.

5. Deſcribe a Circle, about that Line, at any opening of the Compaſſes.

6. Find the Sun's Place in the Ecliptic for the given Day, and mark it upon the Globe.

7. Fix the Quadrant of Altitude in the Zenith of the given Place.

8. Move the Globe and Quadrant together, till the Mark on the Globe and Quadrant meet together.

9. Reckon, upon the Horizon, the Number of Degrees between the graduated Edge of the Quadrant of Altitude, and South-ſide of the Meridian, and ſet them off upon the 'foreſaid Circle (which may readily be done by a Protractor) beginning at that End of the Line, which is toward the Sun, and proceeding, either towards the Right-hand, or the Left, according to the Time of the Day; *i. e.* (yourſelf facing the Sun) towards the Left-hand, if it be Morning, but towards the Right-hand, if it be Afternoon; making a viſible Point in the Circumference, where the Reckoning Ends.

10. Draw a Line from that Point in the Circumference, thro' the Center of the ſaid Circle, and the ſame will be the true Meridian Line of that Place, let the Obſervation be made, at what Time of the Day you pleaſe.

Note 1. In other Latitudes, when the *Meridian* Sun is full North, you muſt reckon the Degrees upon the Horizon, between the Edge of the Quadrant of Altitude, and the North-ſide of the *Meridian.*

2. You muſt alſo ſet off the ſame Number of Degrees towards the Right-hand, if it be Morning, but towards the Left, if it be Afternoon.

3. The beſt Way to prove the Truth of this Operation, is to do the ſame over again at another Hour of the Day, either Morning or Afternoon; and if the ſecond *Meridian Line* falls upon the firſt, or is Parallel to it, it is Right.

PROBLEM XXVIII.

The Month and Day being given, to find thoſe Places of the North frigid Zone, where the Sun begins then to Shine conſtantly without Setting; as alſo thoſe Places of the South frigid Zone, where the Sun then begins to be totally Abſent.

Note, The given Day muſt always be ſome where between the vernal Equinox and Summer-Solſtice, or beween the Autumnal Equinox and Winter-Solſtice.

Given, *May* 17;
Required, thoſe Places in the North frigid Zone, where the Sun begins to Shine without Setting; and thoſe Places in the South frigid Zone, where he begins to be totally abſent.

1. Find the Sun's Place in the Ecliptic for the given Day, and mark it upon the Globe.

2. Bring that Place to the Meridian.

3. Reckon the ſame Number of Degrees on the Meridian, from the North Pole, as there are between the Sun's Place and the Equator, making a Mark on the Meridian, where the Reckoning Ends.

4. Turn the Globe about, and obſerve what Places paſs under the ſaid Mark, which are thoſe, where the Sun begins to Shine without Setting.

5. Set off the ſame Number of Degrees on the Meridian, from the South Pole, and mark as before.

6. Turn the Globe about, and obſerve, what Places paſs under the ſaid Mark, which are thoſe, where the Sun begins totally to diſappear, at the given Day.

Note, The Latitude of any particular Place, being out of the Queſtion, there is no need of rectifying the Globe.

Or thus more conciſely.

1. Find the Sun's Declination for the given Day.

2. Subtract that Declination from 90°, gives the Latitude of all thoſe Places, where the Sun begins to Shine; the ſame Latitude, South, gives the Places, where he begins to be totally Abſent.

PROBLEM XXIX.

A Place being given in the North frigid Zone, to find what Number of Days the Sun ſhines continually there; and alſo the Number of Days he is Abſent, together with the firſt and laſt Days of his Appearance.

Given, the North Cape, in Lat. 71° 27′ N.
Required, how long the Sun ſhines there continually; the Number of Days he is Abſent, and the firſt and laſt Days of his Appearance.

1. Bring the given Place to the Meridian, and mark the Latitude with Chalk, or a Patch.

2. Elevate the Globe to the Latitude of the given Place.

3. Reckon on the Meridian, the ſame Number of Degrees from the Equator (both ways) as the given Place is diſtant from the North Pole, *viz.* 18° 33′.

4. Make Marks, where the Reckonings End.

5. Turn the Globe about, and obſerve, what two Points of the Ecliptic paſs under each Mark in the Meridian, and mark them alſo, *viz.* 23° ♉ and 5° ♌ for the Northern Arch; and 22° ♏, and 10° ♒ for the Southern Arch.

6. For the Northern Arch of the Ecliptic, *viz.* that comprehended between 23° ♉ and 5° ♌; if that be reduced to Time, by Reckoning on the Horizon, it will give the Number of Days that the Sun ſhines conſtantly above the Horizon of the given Place; *viz.* 77 Days.

Note, To reduce this Arch into Time, is to obſerve, what Days of the Month anſwer thoſe two marked Degrees, they being equally Diſtant from the Tropic of ♋, and the Days that are between them, including the firſt and laſt Days, make the Time that the Sun conſtantly Shines, *viz.* from *May* 14*th*, to *July* 28*th*.

7. For the Southern Arch of the Ecliptic, *viz.* that comprehended between 22° of ♏, and 10° of ♒; if that be reduced to Time, it will give the Number of Days that the Sun is totally Abſent, *viz.* 79 Days.

Note, To reduce this Arch into Time, is to obſerve, what Days of the Month, anſwer thoſe two marked Degrees on the Horizon as before, they being equally Diſtant from the Tropic of ♑; and the Days that are between them, including the the firſt and laſt Days, make the Time that the Sun is totally Abſent, *viz.* from *Nov.* 14*th.* to *Jan.* 30*th.* *viz.* 78 Days.

8. The firſt Day of his Appearing at the North Cape, is that Day of the Month, anſwering to that marked Degree between ♈ and ♑, *viz.* 24° of ♏, or *Nov.* 14*th*, and the laſt Day of his Appearing is that Day of the Month, anſwering to that marked Degree, between ♑ and ♎, *viz.* 10° of ♒, or *Jan.* 30*th.*

9. When the Sun is any where in the other two Spaces of the Ecliptic, between the Northern and the Southern Arches, he both Riſes and Sets to the Inhabitants of the ſaid Cape, and of that whole Parallel.

Note, It is to be obſerved, that the Days of the Months, as they are ſet on the Horizon are fixt, and have no regard to the Year, whether it be a common Year, or a Leap-Year; but for that Reaſon it admits of an Exception. Therefore, let it be ſuppoſed that the given Year is the Second after Leap-Year; then it will be

° ′
North-Cape, Lat. 71 27 to be ſubtracted from
90 00

which gives Co. Lat. 18 33 = ☉ Declination, North increaſing; anſwering thereto is, neareſt, *May* 14; decreaſing is *July* 30: Alſo, South increaſing is *November* 15, and decreaſing is *January* 26.

PROBLEM XXX.

The Latitude of a Place, and Day of the Month being given, to find upon what Points of the Compaſs, the Sun will Riſe and Set in that Place and Day.

Given, *London*, in Lat. 51° 32′ N. and *May* 17*th.*

Required, on what Points of the Compaſs the Sun will Riſe and Set then and there.

1. Elevate the Globe to the given Latitude.
2. Find the Sun's Place in the Ecliptic for the given Day.
3. Mark it upon the Globe, and bring it to the Eaſtern Side of the Horizon, which ſhews the Point of it's Riſing, *viz.* N E. by E. ¼ E.
4. Bring the ſame Place to the Weſtern Side of the Horizon, and you may ſee the exact Point of its Setting, at the given Place and Day, *viz.* N. W. by W. ¼ W.

PROBLEM XXXI.

The Latitude of a Place being given, to find the Length of the longeſt and ſhorteſt Days and Nights, in that Part of the World.

Given, *London*, in Lat. 51° 32′ N.

Required, the Length of the longeſt and ſhorteſt Days and Nights there.

1. *For the longeſt Days and ſhorteſt Nights.*

1. Elevate the Globe to the given Latitude.

2. Bring the firſt Degree of ♋ (becauſe that makes the longeſt Day in the North Latitude) to the Eaſtern Side of the Horizon, and fix the Globe.

Note, If the given Place had been in *South Latitude*, then the *South Pole* ſhould be elevated according to the *Latitude* of that Place, and the firſt Degrees of ♑ ſhould be brought to the Eaſtern Side of the Horizon.

3. Set the Index of the horary Circle at Noon.

4. Bring the firſt Point of ♋ to the Weſtern Side of the Horizon, and fix the Globe again.

5. Obſerve the Number of Hours, between the Index and the upper XII, reckoning them according to the Motion of the Globe, which ſhews the Length of the longeſt Day, to be 16 Hours and a half.

6. The Complement of which, to 24 Hours, is the Length of the ſhorteſt Night, *viz.* 7 Hours and a half.

Note, By this Problem is calculated the Table of *Climates*, differing from each other Half an Hour; and the ſmall one, where the *Climates* differ an entire Month from each other.

2. *For the ſhorteſt Days and longeſt Nights.*

1. Elevate the Globe to the given Latitude.

2. Bring the firſt Degree of ♑ (becauſe that makes the ſhorteſt Day in the North Latitude) to the Eaſtern Side of the Horizon, and fix the Globe.

3. Set the Index of the horary Circle at Noon.

4. Bring the firſt Point of ♑ to the Weſtern Side of the Horizon, and fix the Globe again.

5. Obſerve the Number of Hours between the Index and the upper XII, reckoning them according to the Motion of the Globe, which ſhews the Length of the ſhorteſt Day, *viz.* 7 Hours and a half.

6. The Complement of which, to 24 Hours, is the Length of the longeſt Night, *viz.* 16 Hours and a half.

PROBLEM XXXII.

The Length of the longeſt Day, in any particular Latitude being given to find that Latitude.

Given, 16 *hrs.* 30 *min.* for the longeſt Day.
Required, in what particular Lat. that longeſt Day will happen.

1. Bring the firſt Degree of ♋ to the Meridian, and fix the Globe, without regarding the Poſition of it.

2. Set the Index to Noon.

3. Turn the Globe Weſtward, till the Index points at half the Number of Hours given, *viz.* $8\frac{1}{4}$, and fix the Globe again under the Meridian.

4. Move the Meridian upwards and downwards, till the firſt Degree of ♋ coincides with the Horizon.

5. Obſerve what Part of the Meridian is cut by the Horizon, under the North Pole, *viz.* almoſt 52°, which is the Latitude required.

PROBLEM XXXIII.

The Latitude of a Place, and Day of the Month being given, to find the Time of the Riſing and Setting of the Sun, and conſequently the Length of the ſame Day and Night.

Given, *London*, in Lat. 51° 32′ N. and *Aug*. 29.
Required, the Time of the Sun-riſing and Sun-ſetting, and the Length of that Day and Night.

1. Rectify the Globe for the given Latitude.
2. Find the Sun's Place in the Ecliptic for the given Day, *viz.* 6° of ♍, and mark it.
3. Bring the Sun's Place to the Meridian, and fix the Globe.
4. Set the Index of the horary Circle at Noon.
5. Turn the Globe about, till the Sun's Place coincides with the Eaſtern Side of the Horizon, and fix the Globe.
6. The Index ſhews the Time of the Sun's Riſing, *viz.* 5 *hrs.* 15 *min.* nearly,
7. Turn the Globe, till the Sun's Place coincides with the Weſtern Side of the Horizon, and fix it again.
8. The Index ſhews the Time of the Sun's Setting, *viz.* 6 *hrs.* 45 *min.* nearly.
9. Reckon the Hours between Sun-riſing and Sun-ſetting, according to the Motion of the Index from E. to W. and they give the Length of the Day, *viz.* 13 *hrs.* 30 *min.* or double the Hour of Sun-ſetting, gives the Length of the Day.
10. The Complement of the Day to 24 Hours, gives the Length of the Night, *viz.* 10 *hrs.* 30 *min.*

PROBLEM XXXIV.

The Latitude of a Place being given, to find what Climate it is in.

Given, *London*, in Lat. 51° 32′ N.
Required, the Climate of that Place.

1. Find the Length of the longeſt Day for the given Place, by *Prob.* XXXI which is 16 *hrs.* 30 *min.*
2. The Number of half Hours, which that longeſt Day exceeds 12, *viz.* 9 = 4 *hrs.* 30 *min.* gives the Climate deſired, *viz.* 9.

Note 1. This muſt be underſtood of Places, whoſe Latitude does not exceed 66° ½: Where the Latitude is greater, the Climates increaſe by intire Months; and in ſuch Caſe you muſt enter the ſmall Table of Climates, Page 12, with the given Latitude, which ſhews the Climate, and the Length of the longeſt Day at once.

2. The Climates may alſo be diſcovered from the Latitudes of Places, not above 66° ½ by inſpecting the larger Table of Climates, Page 12, as aforeſaid.

PROBLEM XXXV.

The Length of the longeſt Day, in any Place being given, to find the Latitude of that Place nearly.

Given, *London*, whoſe longeſt Day is 16 *hrs.* 30 *min.*
Required, the Latitude of that Place.

Note, This is performed by the Table of Climates.

1. Subtract 12 *hrs.* from 16 *hrs.* 30 *min.* the Remainder is 4 *hrs.* 30 *min.*
2. Four *hrs.* 30 *min.* × 2 = 9 = the Climate.
3. Look for 9 in the Table of Climates, Page 12, and againſt it ſtands 51° 38′.

Or,

Look in the ſame Table for the ſaid longeſt Day, and againſt it ſtands 51° 38′ as before.

Note, This is not exact, neither can it be; becauſe in thoſe *Climates* near the Equator, ſeveral Degrees are included in one *Climate*.

PROBLEM XXXVI.

The Latitude of a Place, and Day of the Month being given, to find the Beginning of the Morning-Twilight, and the End of the Evening-Twilight, with the Duration of both.

Given, *London*, in Lat. 51° 32′ N. and *April 9th*.
Required, the Beginning of the Morning, and End of the Evening-Twilight.

1. Rectify the Globe for the given Latitude.
2. Fix the Quadrant of Altitude in the Zenith.
3. Find the Sun's Place in the Ecliptic for the given Day, and mark it on the Globe.
4. Bring the Sun's Place to the Meridian, and fix the Globe.
5. Set the Index at Noon, or upper XII.
6. Find the Degree of the Ecliptic, which is oppoſite to the Sun's Place for the given Day, by turning the Globe, till the Index points to the lower XII or Midnight, and mark it.
7. Move the Globe, till the Degree, oppoſite to the Sun's Place, and the 18th Degree of the Quadrant of Altitude coincide on the Weſtern Side, and fix it again.
8. Obſerve what Hour the Index points at, which is the Time in the Morning, when Twilight begins, *viz.* about III o'Clock.
9. Turn the Globe, till the ſaid oppoſite Point cuts the Weſtern Side of the Horizon, and fix the Globe again.
10. Obſerve the Index, which Points at 5 *hrs.* 10 *min.* or thereabout, and is the Time of Sun-riſe.
11. The Difference between theſe two Times, ſhews the Duration of the Morning-Twilight, *viz.* 2 *hrs.* 10 *min.*
12. Move the Globe, till the Degree oppoſite to the Sun's Place, and the 18th Degree of the Quadrant of Altitude coincide on the Eaſtern Side, and fix it.
13. Examin the Index, and you have the Time, when the Evening-Twilight Ends, *viz.* about IX o'Clock.
14. Turn the Globe, till the ſaid oppoſite Point cuts the Eaſtern Side of the Horizon, aad fix it again.
15. Obſerve the Hour, which the Index points at, and you will find it 6 *hrs.* 50 *min.* or thereabout, which is the Time of Sun-ſetting, when Twilight begins.

16. The Difference between theſe two Times, ſhews the Duration of the Evening Twilight, *viz.* 2 *hrs.* 10 *min.* as before.

Note 1. The Duration of the Morning and Evening-Twilight, on the ſame Days, is always the ſame.

2. The Reaſon why the 18th Degree of the Quadrant of Altitude, and no other, is to meet the Point oppoſite to the Sun's Place, is, becauſe the Rays of the Sun are Viſible after Sun-ſet, till he is depreſt 18° below the Weſtern Horizon, which is the Ending of the Evening-Twilight: The Morning-Twilight begins when the Sun is 18° below the Eaſtern Horizon, and holds till the Sun-riſes.

3. When the Sun is in the Beginning of ♊ (which is *May 22d*, and ſo continues till he comes to 29° 30′ of ♋, which is *July 22d.*) the oppoſite Point to the Sun's Place is ſo remote, that the 18th Degree on the Quadrant of Altitude will not reach it, by which it appears that the given Latitude is ſo far Northward, as to admit of Twilight all Night long, between *May 22d* and *July 22d.* as aforeſaid.

4. When the Declination of the Sun becomes equal to the Complement of the Latitude, leſſened by the Sun's Depreſſion, the total Darkneſs ceaſes, and the Twilight continues from Sun-ſet to Sun-riſe.

PROBLEM XXXVII.

The Length of the longeſt Day, in any particular Place, being given, to find the Climate in which that Place is, and conſequently all thoſe Places, nearly, whoſe longeſt Day is of the ſame Length.

Note, This is to be conſidered with regard to the Climate only, rather than the Places; for the identical Places themſelves cannot be pointed out; becauſe ſome Climates (as before obſerved) contain ſeveral Degrees of Latitude.

Given 16 *hrs.* 30 *min.* for the longeſt Day.

Required the Climate, and in it thoſe Places having their longeſt Day of the ſame Length.

1. Find the Latitude of the Place, as near as may be, by the given Length, in the Table of Climates, Page 12.

2. Mark that Latitude on the Brazen Meridian.

3. Turn the Globe round, and the Places paſſing under that Mark, are the Places ſought for.

PROBLEM XXXVIII.

A certain Number of Days, not ſurpaſſing 182, being given, to find that Parallel of Latitude, where the Sun ſets not, during thoſe Days.

Note, 182 being the half of 365, is the Reaſon why that Number muſt not be exceeded, becauſe at the Poles, the North Pole eſpecially, the Sun ſets not during that Time.

Given, 160 Days.

Required, that Parallel of Latitude, where the Sun ſets not during that Time.

1. Take half the Number of Days given.

2. With that half reckon ſo many Degrees on the Ecliptic, beginning at the firſt Degree of ♋, either Eaſterly or Weſterly.

3. Make a Mark where the Reckoning Ends.

Note, If the half Number of Days be 30 or upwards, then the Number of Degrees muſt be leſs than it by 1; if the half Number of Days be 60 or upwards, then the Number of Degrees muſt be leſs by 2; and if the half Number of Days be 90, then the Number of Degrees muſt be leſs by 3; becauſe the half of 365 *Days*, 6 *Hours*, being 183 nearly, and the half of 360° but 180°, therefore without ſuch Abatement, the half Number of Days would over-run the half Number of Degrees.

4. Bring the marked Point of the Ecliptic to the Meridian.

5. Obſerve how many Degrees are intercepted between the aforeſaid Point and the Pole, *viz.* 86°.

6. Reckon the ſame Number of Degrees from the Equator towards the North Pole, and that will ſhew the Parallel of Latitude, where the Sun will not ſet for 160 Days.

> *Note* 1. Half the given Number of Days are required to Work with, becauſe you reckon but one way from the firſt Degree of ♋.
>
> 2. If the deſired Parallel of Latitude be South of the Line, the operation is the ſame, by counting the half Number of Days from the firſt Degree of ♑.

PROBLEM XXXIX.

The Latitude of a Place, Day of the Month, and Hour of the Day, being given, to find the *Italic* Hour.

> *Note*, The *Italic* Hours are reckoned from 1 to 24 at all Times, from Sun-ſetting of one Day, to Sun-ſetting the next.

Given, *London*, in Lat. 51° 32′ N. *May* 18*th*. at V. P. M.

Required, the *Italic* Hour, anſwering to the given Hour.

1. Rectify the Globe for the given Latitude.

2. Find the Sun's Place in the Ecliptic for the given Day, and mark it on the Globe.

3. Bring the Sun's Place to the Meridian, and fix the Globe.

4. Set the Index of the horary Circle at Noon.

5. Turn the Globe Weſt (becauſe it is Afternoon) till the Index points at the given Hour, and fix it again.

6. Set the Index again at Noon.

7. Turn the Globe Eaſtward, till the Mark of the Sun's Place in the Ecliptic touch the Weſtern Horizon, and fix it again.

8. Obſerve the Hour, which the Index points at; and reckon how many Hours are between the upper XII. and the Index, reckoning them Eaſtward, according to the laſt Motion of the Globe, and they will be the Number of Hours from Sun-ſet the Day before; the laſt being the *Italic* Hour deſired, *viz.* 21 *hrs.* 10 *min.*

ARITHMETICALLY.

	hrs.	*min.*	
May 18, *Sun ſets* –	7	50	
Which ſubtract from	12	0	
Remainder is – –	4	18	*after Sun-ſet.*
Add – – – – – –	12	0	*for the next Morning Hours.*
And – – – – – –	5	0	– – – *Afternoon.*
Sun is – – – – –	21	10	*after Sun-ſet.*

PROB-

PROBLEM XL.

The Latitude of a Place, Day of the Month, and *Italic* Hour, being given, to find the Hour of the Day at the given Place.

Given, *London*, in Lat. 51° 32′ N. *May* 19*th*, and *Italic* Hour, 21 *hrs.* 10 *min.*

Required, the Hour of the Day at that Place.

1. Rectify the Globe for the given Latitude.
2. Find the Sun's Place in the Ecliptic, and mark it on the Globe.
3. Bring it to the Meridian, and fix the Globe.
4. Set the Index of the Hour Circle at the *Italic* Hour given, reckoning from the uppermoſt XII. round about, according to the natural Order of the Index.
5. Turn the Globe Weſtward, till the Sun's Place come to the Weſtern Side of the Horizon, and fix it.
6. Obſerve the Index, which points to V. P. M. the Hour required.

Or thus;

1. By *Prob.* XXXII. find the Hour of Sun-ſet for the preceding Day, *viz.* 7 *hrs.* 50 *min.*
2. Turn the Globe Weſtward, till 21 *hrs.* 10 *min.* have paſſed, by the Index, from Sun-ſet, and fix it.
3. Obſerve the Hour pointed at, on the horary Circle, which is V. P.M. of the given Day.

PROBLEM XLI

The Latitude of a Place, Day of the Month, and Hour of the Day, being given, to find the *Judaical* Hour, adequate to the given Hour.

Note 1. The *Judaical* Hour is the Time of the Day, according to the Cuſtom of the antient *Jews.*

2. Thoſe *Jews* divided their artificial Day into 12 Hours, and their Night into 12 Hours, which Number of Hours proved unequal in Extent every Day and Night (except exactly under the Equator) thoſe Days and Nights increaſing and decreaſing, according to the Seaſons of the Year; or, which is the ſame Thing, according to the various Declinations of the Sun from the Equator, either Northward or Southward.

1. *For the Morning.*

Given, *London*, in Lat. 51° 32′ N. *May* 26*th.* at IX. A.M.

Required, the *Judaical* Hour at that Time.

1. Rectify the Globe for the given Latitude.
2. Find the Sun's Place in the Ecliptic for the given Day, and mark it on the Globe.
3. Bring it to the Eaſtern Horizon, and fix the Globe.
4. Set the Index of the horary Circle at Noon.
5. Bring the Sun's Place to the Weſtern Horizon, and fix the Globe again.
6. Obſerve the Number of Hours, between Noon and the Index, reckoning Weſterly; thoſe being the Hours, of which, the given Day doth conſiſt, *viz.* 16, which Note down.

7. Find the Time of Sun-riſing, by *Prob.* XXXII. *viz.* IV. A. M.
8. Find the Number of Hours between Sun-riſing, and the given Hour for the given Day, *viz.* 5 *hrs.*
9. Obſerve the following Proportion, *viz.*

As all the Hours of the given Day :
Are to 12, the Length of the *Judaical* Day : :
So are the Hours between Sun-riſing, and the given Hour :
To the *Judaical* Hour required, *viz.* 3 *hrs.* ¾.

hrs.		*hrs.*		*hrs.*		*hrs.*
16	:	12	: :	5	:	3 ¾.

2. *For the Afternoon, before Sun-ſet.*

Given, *London*, and the Day, as before, at VII. P. M.
Required, the *Judaical* Hour.

1, 2, 3, 4, 5, 6, 7, as before.
8. Find the Number of Hours between Sun-riſing, and the given Hour, *viz.* XV.
9. As before, *viz.* 11 *hrs.* ¼.

hrs.		*hrs.*		*hrs.*		*hrs.*
16	:	12	: :	15	:	11 ¼.

3. *For the Night*, i. e. *any Time between Sun-ſet and Sun-riſe.*

Given, *London*, and the Day, as before, at XI. P. M.
Required, the *Judaical* Hour at that Time.

1, 2, 3, 4, 5, 6, as before. 7. Find the Number of Hours, of which the Night doth conſiſt, *viz.* 8 *hrs.* which Note.
8. Find the Number of Hours between Sun-ſet, and the given Hour for the given Day, *viz.* 3 *hrs.*
9. Obſerve the following Proportion, *viz.*

As all the Hours of the given Night :
Are to 12, the Length of the *Judaical* Night : :
So are the Hours between Sun-ſet and the given Hour,
To the *Judaical* Hour required ; *viz.* 4 ½ Hours.

hrs.		*hrs.*		*hrs.*		*hrs.*
8	:	12	: :	3	:	4 ½.

Hence, as the Night is ſhorter than the Day, and 12 *Judaical* Hours, (in this Caſe) make but 8 Hours with us, it muſt follow that the *Judaical* Hours are ſhorter than ours ; conſequently when it is Eleven at Night with us, on the given Day, the *Judiacal* Hour is 4 *hrs.* ½ after Sun-ſet, or half an Hour after 4 at Night.

PROBLEM XLII.

The Latitude of a Place, Day of the Month, and *Judaical* Hour, being given, to find the Hour of the Day at the Place given.

1. *For the Day,* i. e. *between Sun-riſe and Sun-ſet.*

Given, *London,* in Lat. 51° 32′ N. *May 26th,* and *Judaical* Hour, 3 *hrs.* ¾.

Required, the Hour of the Day correſponding thereto at the given Place.

1, 2, 3, 4, 5, 6, as the laſt *Problem.*
7. Bring the Sun's Place to the Meridian.
8. Set the Index at Noon.
9. Bring the Sun's Place to the Eaſtern Horizon, and fix the Globe.
10. Obſerve what Hour the Index points at, *viz.* IV. on the Eaſtern Side of the Hour-circle, which is the Hour of Sun-riſe at the given Place.
11. Uſe the following Proportion, *viz.*

As the Length of the *Judaical* Day :
Is to the given *Judaical* Hour : :
So is the Length of the Day at the given Place :
To a fourth Proportional.

hrs. *hrs.* *hrs.* *hrs.*
12 : 3¾ : : 16 : 5
Alſo 12 : 11¼ : : 16 : 15

12. If the fourth Proportional is leſs than 12, add the Hour of Sun-riſing to it, *viz.* 4, and the Sum is the Hour of the Day before Noon.

thus, $5 + 4 = 9$ A. M.

13. If the fourth Proportional is more than 12, ſubtract 12 from it, and add the Hour of Sun-riſing to that Remainder ; the Sum is the Hour of the Day in the Afternoon.

thus, $15 - 12 + 4 = 7$ P. M.

2. *For the Night,* i. e. *between Sun-ſet and Sun-riſe.*

Given, *London,* in Lat. 51° 32′ N. *May 26th.* and *Judaical* Hour 4½.

Required, the Hour of the Night, correſponding thereto at the given Place.

1, 2, 3, 4, 5, 6, 7, 8, as before.
9. Bring the Sun's Place to the Weſtern Horizon, and fix the Globe.
10. Obſerve what Hour the Index points at, *viz.* VIII. on the Weſtern Side of the Hour-circle, which is the Hour of Sun-ſet at the given Place.
11. Uſe the following Proportion, *viz.*

As the Length of the *Judaical* Night :
Is to the given *Judaical* Hour : :
So is the Length of the Night at the given Place ;
To a fourth Proportional.

hrs. *hrs.* *hrs.* *hrs.*
12 : 4½ : : 8 : 3

12. If the fourth Proportional is leſs than 12, add the Hour of Sun-ſet to it, and that Sum is the Hour of the Night, before Midnight.

Thus, 3 + 8 = 11 P. M.

13. If the fourth Proportional is more than 12, ſubtract 12 from it, and add the Hour of Sun-ſet to that Remainder, the Sum is the Hour of the Morning before Sun-riſe.

PROBLEM XLIII.

A Place being given to find all thoſe, which have the ſame Hour of the Day, with that in the Place given; as alſo thoſe that have the contrary Hour at the ſame Time: that is, when it is Noon in the given Place, to find where it is Midnight in others.

Given, *London*.

Required, all thoſe Places, which have the ſame Hour; and all thoſe Places, which have the contrary Hour: Or, which is the ſame Thing, have Midnight when it is Noon at *London*.

1. Bring *London* to the Meridian, and fix the Globe.

2. Obſerve what Places are exactly under the Eaſtern Side of the upper Semi-Circle of the ſaid Meridian, for thoſe Places, always have the ſame Hour with *London*, at all Times of the Day.

3. Set the Index at Noon.

4. Turn the Globe, till the Index comes to the lower XII. which ſignifies Midnight, and fix it.

5. Obſerve what Places lie under the Eaſtern Side of the upper Semi-Circle of the Meridian; for thoſe Places have their Hours contrary to the Hour at *London*; and when it is Noon at *London*, it is always Midnight in thoſe Places laſt found.

Note, In this *Problem*, the Globe may be rectified for the Latitude of the given Place, or omitted; it being of no Moment either Way.

PROBLEM XLIV.

A Place being given, with the Hour of the Day at that Place, to find all thoſe Places, where it is Noon, Midnight, or any other particular Hour at the ſame Time.

Given, *London*, VII. A. M. any Day:

Required, all thoſe Places where it is Noon, Midnight, VII. P. M. and X. A. M. at the ſame Time.

1. Bring *London* to the Meridian, and fix the Globe.

2. Set the Index at the given Hour.

3. Turn the Globe, till the Index points at Noon, and fix it again.

4. Obſerve what Places are under the Eaſtern Side of the upper Semicircle of the Meridian; for in them it is Noon at the given Time.

5. Turn the Globe, till the Index points at Midnight, and fix it.

6. Obſerve what Places lie under the Meridian as before, for in them it is Midnight.

7. Turn the Globe, till the Index points at VII. P. M. and fix it.

8. Obſerve what Places are under the Meridian as before; for in all thoſe Places it is VII. P. M.

9. Turn the Globe, till the Index points at X. A. M. and fix it.

10. Obſerve what Places are under the Meridian again; for in all thoſe Places it is X. A. M.

PROBLEM XLV.

The Latitude of a Place, Day of the Month, and Hour of the Day, being given to find all thoſe Places, where the Sun riſes at that Time, and where he ſets; thoſe Places that are enlightened, and thoſe that are in Darkneſs.

Given, *London*, in Lat. 51° 32′ N. *June* 11*th*. at IX. A. M. Required, all thoſe Places where the Sun riſes and ſets; and where it is Day and Night, all at the ſame Time.

1. Elevate the Pole to the given Latitude.
2. Find that particular Place over which the Sun is vertical at the Time given, by *Prob.* XVII. *viz. Cariathaim* in *Arabia*, or near it.
3. Bring that Place to the Meridian, and fix the Globe.
4. Obſerve what Places are in the Weſtern Semi-circle of the Horizon; for in them the Sun riſes at the given Time, he being 90° diſtant from them to the Eaſtward.
5. Obſerve what Places are in the Eaſtern Semi-circle of the Horizon; for in them the Sun ſets at that Time, he being alſo 90° diſtant from them to the Weſtward.
6. Thoſe under the upper Meridian have Mid-day, and conſequently,
7. Thoſe on the upper Hemiſphere of the Globe are enlightened.
8. Thoſe under the lower Meridian have Midnight, and conſequently,
9. Thoſe on the lower Hemiſphere are in Darkneſs.

PROBLEM XLVI.

The Latitude of a Place, Day of the Month, with the Moon's Latitude and Place in the Ecliptic, being given to find the Time when the Moon ſhall riſe, ſet and ſouth, or come to the Meridian of the given Place.

Given, *London*, in Lat. 51° 32′ N. *June* 14*th*. the Moon 20° 26′ in ♓ Piſces, and her Latitude 3° 58′ *Auſtralis* or South. Required, the Moon's Riſing, Setting, and Southing.

Note, The Moon's Place, and her Latitude, which is her neareſt Diſtance from the Ecliptic, may be readily found againſt the Day of the Month in an Ephemaris.

1. Rectify the Globe for the given Latitude.
2. Find the Sun's Place in the Ecliptic for the given Day, and mark it on the Globe.
3. Bring it to the Meridian, and fix the Globe.
4. Set the Index of the horary Circle at Noon.
5. Find the Moon's Place in the Ecliptic, regarding her Latitude, and mark it on the Globe alſo.
6. Turn the Globe, till the Moon's Place coincides with the Eaſtern Side of the Horizon; then will the Index ſhew the Hour of the Moon's Riſing, *viz.* 12 *hrs.* 45 *min.* at Night.
7. Bring the Moon's Place to the Meridian; then will the Index ſhew the Southing, *viz.* 6 *hrs.* 00 *m.* A. M.

8. Bring the Moon's Place to the Weſtern Side of the Horizon; then will the Index ſhew the Hour of the Moon's Setting, *viz.* 11 *hrs.* 15 *min.* A. M.

Note, This *Problem* ſerves to determin the Riſing, Setting, and Southing of the Planets, as well as of the Moon; ſuch Planets Places being firſt known by an *Ephemeris*.

PROBLEM XLVII.

The Day and Hour of a Solar *Eclipſe* being given, to find all thoſe Places, in which the ſame will be Viſible.

Given, an Eclipſe of the Sun, *April 24th.* 1762, at 5 *hrs.* 30 *min.* A. M.

Required, all thoſe Places, where it will be Viſible.

1. Find the Sun's Place in the Ecliptic for the given Day, and mark it on the Globe.
2. Find that particular Place of the Globe, to which the Sun is vertical at the given Time, by *Prob.* XVII.
3. Bring that Place to the Meridian.
4. Raiſe the Pole to the Latitude of that Place, and fix the Globe.
5. Obſerve what Places are in the upper Hemiſphere, for in moſt of them will the Eclipſe be Viſible, except thoſe in the Horizon, or very near it.

Note, This is to be underſtood chiefly of great *Eclipſes*; that is, when the Sun is totally Eclipſed, or nearly ſo: but when the *Eclipſe* is ſmall, that is, only three or four Digits of the Sun eclipſed, ſuch *Eclipſe*, in many Places, far above the Horizon, will not be ſeen; and in others juſt diſcernible: And even a central *Eclipſe* is not ſo every where; but in ſome Places it is central, in ſome partial, and in others there is no *Eclipſe* at all.

PROBLEM XLVIII.

The Day and Hour of a Lunar *Eclipſe* being given, to find all thoſe Places in which the ſame will be Viſible.

Given, an *Eclipſe* of the Moon, *May 8th.* 1762, at 3 *hrs.* 54 *min.* A. M.

Required, all thoſe Places where that *Eclipſe* will be Viſible.

1. Find the Sun's Place in the Ecliptic for the given Day.
2. Mark the Place oppoſite thereto, which is the Moon's Place at that Time, without regarding her Latitude, which in this Caſe ſignifies little or nothing.
3. Find that Place upon the Globe to which the Sun is vertical at that Time.
4. Find the *Antipodes* of that Place, and mark it.
5. Bring ſuch *Antipodes* to the Pole of the wooden Horizon; *i. e.* elevate the Pole to the Latitude of that *Antipodes*, and bring it to the Meridian.
6. Fix the Globe in that Situation.
7. Obſerve what Places are in the upper Hemiſphere of the Globe, for in ſuch will the *Eclipſe* be Viſible, except thoſe in, or very near the Horizon.

Note, Obſerve the ſame *Note* here, which was given at the End of the laſt *Problem*.

PROB-

PROBLEM XLIX.

To find the Angle of Poſition between any two Places.

Note 1. The Angle of Poſition of two Places, is the Angle that the Arch of a great Circle paſſing over the two Places, makes with the Meridian of that Place in the Zenith. Or,

2. It is an Arch of the Horizon intercepted between the two containing Sides, *viz.* the Quadrant of Altitude and the Meridian.

Given, *London* and *Rome*,
Required, the Angle of Poſition between them.

1. *At London.*

1. Rectify the Globe for *London.*
2. Bring *London* to the Meridian, and fix the Globe.
3. At the Latitude of *London,* fix the Quadrant of Altitude.
4. Lay the graduated Edge to *Rome,* and continue it till it cut the Horizon, which will be S. E. $\frac{1}{4}$ E. $= 4\frac{1}{4}$ Points $= 47^\circ\ 49'$.

2. *At Rome.*

1. Rectify the Globe for *Rome.*
2. Bring *Rome* to the Meridian, and fix the Globe.
3. At the Latitude of *Rome,* fix the Quadrant of Altitude.
4. Lay the graduated Edge to *London,* and continue it till it cut the Horizon, which will be N. W. by N. $\frac{1}{2}$ W. $= 3\frac{1}{2}$ Points $= 39^\circ\ 22'$.

Note 1. The Eaſt and Weſt Rhumb Lines, on the Equator, make equal Angles with all Meridians on the Globe. But,

2. A great Circle drawn thro' the Vertex of any Place, that is diſtant from the Equator, cannot cut divers Meridians at equal Angles.

3. As it is the known Property of Rhumb-Lines to make equal Angles with all Meridians, and as the Meridians are inclining Circles, meeting in the Poles; it follows that the ſaid Rhumbs muſt be *Loxodromie* or ſpiral Lines.

4. If a Ship ſails due North or South, ſhe changes her Horizon, but not her Meridian, and forms a great Circle. If ſhe ſails on any other Point of the Compaſs, ſhe changes both Horizon and Meridian. If ſhe ſails due Eaſt or Weſt, on the Equator, ſhe forms a great Circle that Way alſo. If ſhe ſails on any other Rhumb between the Cardinals, which inclines to the Meridian, ſhe not only changes her Horizon and Meridian, but alſo deviates from a great Circle, and forms a ſpiral Line, winding itſelf about that Pole it inclines to, without ever being able to arrive at it.

5. As the Latitudes of the two given Places are different, the Angle of Poſition at each Place, muſt be different alſo: But if the Latitude at both Places had been the ſame, the Quantities of the Angles would have been the ſame likewiſe.

PROBLEM L.

The Latitude of a Place being given to find all other Places that are ſituate from the ſame upon any Point of the Compaſs given.

Given, *London,* in Lat. $51^\circ\ 32'$ N.
Required, all thoſe Places, which are S. E. N. by E. S. W. by S. and W. N. W. of the ſame.

1. Rectify the Globe for the given Latitude.
2. Bring the given Place to the Meridian, and fix the Globe.

3. Fix the Quadrant of Altitude in the Zenith.

4. Apply the lower Part thereof to the given Point of the Compaſs on the Horizon.

5. Obſerve what Places are exactly under the Edge of the ſaid Quadrant, for thoſe are the Places that are ſituate or bear from the given Place, according to the given Point.

PROBLEM LI.

Two Places being given, to find the true Diſtance between them.

Note 1. The given Places muſt, of Neceſſity, either lie under the ſame *Meridian*; *i. e.* differ only in Latitude. Or,

2. They muſt lie under the ſame *Parallel*, *i. e.* differ only in Longitude. Or,

3. They muſt have different *Meridians* and different *Parallels*, and ſo differ both in Latitude and Longitude. Or,

4. They muſt lie under the *Equator*, where their Diſtance is their Difference of Longitude.

I. Two Places under the ſame Meridian.

1. *In the ſame Sort of Latitude.*

		°	′		
Given, *Shakaiſchick*,	in Lat.	53	0	N.	In the Weſtern Parts of *Tartary*.
Munkiſchalk,	in Lat.	44	45	N.	

Required, the Diſtance between them.

1. Bring both Places to the Meridian.

2. The Diſtance between them are the Degrees, which reduced into Miles will give 495 Miles for the Diſtance.

ARITHMETICALLY.

Subtract the leſſer Latitude from the greater, the Difference reduced into Miles is the Anſwer.

° ′
53 0
44 45
―――
8 15
60
―――
495 *Miles nautical.*

Note 1. If Geographical or Statute Miles are required, the 'foreſaid 8° 15′ muſt be multiplied by 69 $\frac{1}{2}$.

2. If the given Places differ but a little in Longitude; *i. e.* be not exactly under the ſame *Meridian*, the foregoing Proceſs will hold nearly good.

2. *In different Sorts of Latitude.*

Given, *Smyrna*, in Lat. 38° N. in the Weſtern Part of *Natolia*, and *Monomotapa*, in Lat. 19° S. in *Monomotapa*.

Required, the Difference of Latitude, or Diſtance between them.

1, 2, by the Globe, as before.

ARITH-

ARITHMETICALLY.

Add the two Latitudes together, the Sum is the Diſtance in Degrees, which reduced into Miles is the Anſwer.

$$\overline{38+19}\times 60 = 3420 \text{ Miles nautical.}$$

II. Two Places under the ſame Parallel.

1. *In the ſame Sort of Longitude.*

Given, *Cambridge*, in *England*, in Long. $1^\circ\frac{1}{4}$ E.
Tolembi, in the Eaſtern Part of *Tartaria magna*, in Long. 114° E. } Lat. $52^\circ\frac{1}{2}$ North.
Required, the Diſtance between them.

1. Bring both Places to the Meridian, and make Marks on the Equator where their Meridians cut it.

2. The Diſtance between thoſe Marks or Meridians, on the Equator, in Degrees, is equal to the Diſtance between the given Places in Degrees alſo, upon their proper Parallel.

3. Find how many Miles make a Degree of Longitude in the Latitude given, by the Table, at p. 14, *viz.* 36.53 Miles.

4. Multiply the Degrees of Longitude, between the given Places, by 36.53, the Product is the Anſwer, in Miles.

ARITHMETICALLY.

Subtract the leſſer Longitude from the greater; the Difference is the Degrees between the two given Places; which, multiply, by 36.53, as above, the Product is the Anſwer.

$$\overline{114-\overset{\circ}{1}\ \overset{\prime}{15}}\times 36.53 = 4118.7575 \text{ Miles.}$$

Note, If the given Places ſhould differ a little in Latitude, *i. e.* be not exactly under the ſame Parallel, the foregoing Proceſs will, nearly, hold Good.

2. *In different Sorts of Longitude.*

Given, *Caſſan*, in Long. 11° W.
Siam, in Long. 102° E. } Latitude 14° N.
Required, the Diſtance between them.

1, 2, 3, 4, by the Globe, as before.

ARITHMETICALLY.

Add their Longitudes together; the Sum is the Anſwer in Degrees; which, multiply, by 58.22 Miles (the Quantity of a Degree in the Parallel of 14°) the Anſwer will be 6579 Miles nearly.

$$\overline{11+102}\times 58.22 = 6578.86 \text{ \textit{Miles.}}$$

III. Two

III. Two Places having different Meridians and different Parallels.

° ′ ° ′

Given, *Borneo*, in Lat. 4 30 N. Long. 113 0 E.
Jeruſalem, in Lat. 32 0 N. Long. 5 30 E.
Required, the Diſtance between them.

1. Bring either of the given Places, at Pleaſure, to the Meridian, and fix the Globe.

2 Fix the Quadrant of Altitude over that Place brought to the Meridian.

3. Bring the graduated Edge of the Quadrant of Altitude to the other Place.

4. Obſerve the Number of Degrees, *viz.* 76, on the Quadrant, between the two Places, which being multiplied by 60, gives 4560 nautical Miles; or by $69\frac{1}{2}$, gives 5282 Geographical, or Statute Miles for the Anſwer.

Note, The Operation is exactly the ſame, if the Latitudes had been, one North and the other South; and their Longitudes, one Eaſt and the other Weſt.

IV. Two Places lying under the Equator.

Given, the Eaſt and Weſt Sides of the *Iſland Borneo*, under the Equator.

Required, the Diſtance between them, *i. e.* the Width of that *Iſland* there.

1. Reckon the Degrees between the two given Sides, *viz.* 8°.

2. Thoſe Degrees, multiplied by 60, give 480 nautical Miles; or by $69\frac{1}{2}$, give 556 Statute Miles for the Anſwer.

Note, The *nautical Mile* is greater than the common or Geographical *Statute* meaſured *Mile*: The Reaſon of which is, becauſe a Degree on any great Circle is divided into 60 Parts or Miles, each of which Miles contains 6116 Feet; whereas the common *Statute Mile*, contains no more than 5280 Feet; and therefore, according to Obſervation, a Degree makes $69\frac{1}{2}$ ſuch Miles. Hence as the ſixtieth Part of a Degree muſt be more than a Sixty-ninth Part, or Seventieth Part nearly; ſo the *nautical Mile* muſt be longer than the *Statute Mile*, as appears by the following Operation.

69.5 Miles = 1 Degree = 366960 Feet.
60)366960(6116 *Feet in* 1 *nautical Mile.*
69.5)366960(5280 *Feet in* 1 *Statute Mile.*

PROBLEM LII.

A Place, and its true Diſtance, from a ſecond Place being given, to find all other Places that are of the ſame Diſtance, from the given Place.

Given, *London*, in Lat. 51° 32′ N. and any Place 1800 Miles diſtant from it.

Required, all thoſe Places, that are at the ſame Diſtance from *London*.

1. Reduce the given Miles into Degrees, at 60 to a Degree.
2. Bring the given Place to the Meridian, and fix the Globe.
3. Fix the Quadrant of Altitude in the Zenith of the given Place.

4. Mark the given Degree on the Quadrant, reckoning backward from the Zenith; *i. e.* the Complement.

5. Move the Quadrant quite round, on the Surface of the Globe, and obſerve what Places the ſaid Mark paſſes over, which are the Places deſired.

Note 1. If one Foot of a pair of Compaſſes be ſet upon the given Place, and the other opened to the given Diſtance, and paſſed round about, it will ſhew the ſame Places.

2. If the Diſtance from the given Place ſhould exceed 90°, you muſt fix the Quadrant on the *Antipodes* of the given Place, and mark it with the Complement of the given Diſtance to 180 Degrees, but backward from the Zenith, as before.

3. The Globe need not be rectified, ſince any convenient Poſition will admit of an Anſwer.

Given, *London*, in Lat. 51° 32′ N. and 7200 Miles diſtant from it. Required, all thoſe Places that are at the ſame Diſtance from *London*.

1. Reduce the given Miles into Degrees.
2. Find the *Antipodes* to *London*, by *Prob.* 19. page 37.
3. Elevate the South Pole to the Latitude of ſuch *Antipodes*.
4. Bring ſuch *Antipodes* to the Meridian, and fix the Globe.
5. Fix the Quadrant of Altitude in the Zenith.
6. Subtract the Degrees laſt found from 180°, and mark them on the Quadrant, reckoning from the Zenith.
7. Move the Quadrant round, &c. as before.

PROBLEM LIII.

A Place, its Latitude and true Diſtance from a ſecond Place, together with the Latitude of the ſecond Place being given to find that Place.

Given, *Madrid*, the Capital City of *Spain*, in Lat. 40° 26′ N. diſtant 41 Degrees from another Place, lying Eaſterly, in Lat. 37° 30′ N. Required, that Place.

1. Rectify the Globe for the given Place, and fix it.
2. Fix the Quadrant of Altitude in the Zenith.
3. Mark the given Diſtance thereon, reckoning backward from the Zenith.
4. Let a Piece of fine pointed Chalk, black lead Pencil, or any other ſuch like Thing; be held againſt the Latitude of the required Place, on the Eaſtern Side of the Meridian, in ſuch Manner, that by turning the Globe Weſterly, it may deſcribe an Arch of a Circle of a convenient Length.
5. Bring *Madrid* again to the Meridian, and fix the Globe.
6. Move the Quadrant of Altitude, till the 41 Degrees, marked on the Quadrant, cut the ſaid Arch, which Interſection is the Place required, *viz.* near the South Weſtern Shoar of the *Caſpian Sea*, in Long. 50° E.

PROBLEM LIV.

A Place, its Latitude and true Diſtance from a ſecond Place, together with the Longitude of the ſecond Place being given to find that Place.

Given, *Paris*, the Capital City of *France*, in Lat. 48° 50′ N. diſtant 50° from another Place, in Long. 28° 30′ Weſt of the Meridian of *London*.

Required, that Place.

1. Rectify the Globe for the given Place, and fix it.
2. Fix the Quadrant of Altitude in the Zenith.
3. Mark the given Diſtance thereon, reckoning backward from the Zenith.
4. Bring the given Longitude to the Eaſt-ſide of the Meridian, and with a black lead Pencil, or fine pointed Chalk, deſcribe an Arch of a Circle, at Pleaſure, along the Meridian.
5. Bring *Paris* to the Meridian again, and fix the Globe.
6. Move the Quadrant of Altitude, till the Diſtance, marked thereon, cut the ſaid Arch, which point of Interſection is the Place required, *viz.* a Point in the Sea S. W. of *Cape Verd Iſlands*, in Lat. 7° N.

PROBLEM LV.

One Place, and the Latitude of another Place unknown, and its bearing from the given Place, by an Angle of Poſition being given, to find that Place, and the Diſtance between them.

Given, *London*, in Lat. 51° 32′ N. and an unknown Place, bearing from *London*, according to an Angle of Poſition, S. E. by E. ½ E. in Lat. 31° 11′ N.

Required, that Place, and the Diſtance between them.

1. Rectify the Globe for the given Place, and fix it.
2. Fix the Quadrant of Altitude over it.
3. Extend the Quadrant to the given Point on the Horizon.
4. With pointed Chalk, or a black lead Pencil, draw a Line or Arch on the Globe, along the graduated Side of the Quadrant, at Pleaſure.
5. Mark the Latitude of the required Place on the Meridian.
6. Turn the Globe, till the Latitude of the required Place interſect the ſaid Line or Arch.
7. The Point of Interſection is the Place required, *viz. Alexandria.*
8. Bring *London* to the Meridian, and fix the Globe.
9. Apply the Quadrant of Altitude to the two Places, and the graduated Edge will ſhew the Diſtance required, *viz.* 31° = 1860 Miles, at 60 to a Degree.

The forementioned Problem *reverſed.*

Given, *Alexandria*, in Lat. 31° 11′ N. and an unknown Place, bearing from *Alexandria*, according to an Angle of Poſition, N. W. by N. ½ W. in Lat. 51° 32′ N.

Required, that Place, and the Diſtance between them.

1, 2, 3, 4, 5, 6, as before.

7. The Point of Interſection is the Place required, *viz. London.*
8. Bring *Alexandria* to the Meridian, and fix the Globe.
9. As before.

PROBLEM LVI.

Two Places, with their Latitudes, and the reſpective Bearing of a third Place (unknown) from them, according to the Angle of Poſition, being given to find that Place, with its Diſtance from the two given Places.

1. *The given Places being under the ſame Meridian.*

Given, *Erivan*, in *Perſia*, in Lat. 40° 30′N. and *Cariathaim*, in *Arabia*, in Lat. 23° N. with the Bearing of the unknown Place, from *Erivan*, E. S. E. ¾ E. and from *Cariathaim*, E. N. E. ¾ E. by two ſeveral Angles of Poſition.

Required, that Place, with its Diſtance from the given Places.

1. Rectify the Globe for the Latitude of *Erivan*.
2. Bring *Erivan* to the Meridian, and fix the Globe.
3. Fix the Quadrant of Altitude in the Zenith.
4. Lay the Quadrant, E. S. E. ¾ E.
5. With a pointed Piece of Chalk, or black lead Pencil, draw a fine Line along the graduated Side of the Quadrant.
6. Rectify the Globe for the Latitude of *Cariathaim*.
7. Bring that to the Meridian, and fix the Globe again.
8. Fix the Quadrant of Altitude in the Zenith.
9. Lay the Quadrant, E. N. E. ¾ E.
10. Draw a fine Line, as before, along the Side of the Quadrant to interſect the former Line.
11. The Interſection will fall upon *Agra* in *India*.
12. Lay the Quadrant of Altitude, from *Erivan* to *Agra*, and the Diſtance between them is 33° = 1980 Miles.
13. Lay the ſame Quadrant, from *Cariathaim* to *Agra*, and the Diſtance between them, is 32° ½ = 1773.85 Miles.

Note, As *Cariathaim* and *Agra*, lie nearly under the ſame Parallel; by conſulting the Table of Parallels, p. 14, it will appear that about 54.58 Miles, at a Medium, go to a Degree in thoſe Latitudes.

		°		*Miles.*
thus,	*Cariathaim*	23	=	55.23
	Agra - -	26	=	53.93
			2)	109.16 (54.58.

2. *The given Places being under the ſame Parallel.*

Given, *Cape Verd* and *Secmara*, in *Nigritia*, both in Lat. 15° N. with the Bearing of the unknown Place, from *Cape Verd*, S. E. by S. a little E. and from *Secmara*, S. by E. ½ E. by two ſeveral Angles of Poſition.

Required, that Place, with its Diſtance, from the given Places.

Proceed in all Reſpects, as before, and you will find the Place required to be the *Cape of Good-Hope*, diſtant from *Cape Verd*, 61 ½ = 3690 Miles; and from *Secmara* 51° = 3060 Miles.

3. *The given Places being under different Meridians and different Parallels.*

Given, *Morocco*, in Lat. 31° N. and *Warſaw*, in *Polonia*, in Lat. 52° N. with the Bearing of the unknown Place, from *Morocco*, E. by N. ⅓ E. and from *Warſaw*, E. S. E. ½ E. by two ſeveral Angles of Poſition.

Required, that Place, with its Diſtance from the given Places.

Proceed, as before, and you will find the Place required to be *Candy* in the *Iſland* of *Ceylon*, diſtant from *Morocco*, 84° ½ = 5070 Miles; and from *Warſaw*, 65° ½ = 3930 Miles.

Note, This *Problem*, might have been ſhortened; but it was for the Learner's ſake, that I gave it in its full Length.

PROBLEM LVII.

A Place, and its Latitude being given, to find how all other Places bear from that Place, by ſo many Angles of Poſition.

Given, *London*, in Lat. 51° 32′ N.

Required, the Bearing of *Rome*, *Madrid*, and *Boſton* in *New-England* from the given Place; by as many ſeveral Angles of Poſition.

1. Elevate the Pole to the Latitude given.
2. Bring *London* to the Meridian, and fix the Globe.
3. Fix the Quadrant of Altitude in the Zenith of the given Place.
4. Lay it from *London* to *Rome*; ſo will *Rome* bear S. E. ¼ E.
5. Lay it from *London* to *Madrid*; ſo will *Madrid* bear S. by W. And,
6. Lay it from *London* to *Boſton*; ſo will *Boſton* bear W. N. W. ¼ W.

PROBLEM LVIII.

Several Places, and their Latitudes being given, to find how any one particular Place bears from them all, by as many Angles of Poſition.

		°	′	
Given, *Rome*, in *Italy* - - -	in Lat.	41	54	N.
Madrid, in *Spain* - -	in Lat.	40	25	N.
Boſton, in *New-England*	in Lat.	42	34	N.

Required, how *London* bears from them all.

1. Elevate the Pole for the Latitude of *Rome*.
2. Bring *Rome* to the Meridian, and fix the Globe.
3. Fix the Quadrant of Altitude in the Zenith of the given Place.
4. Lay the Quadrant, from *Rome* to *London*; ſo will *London* bear N.W. by N. ½ W. from *Rome*.
5. Let all the ſame be done for *Madrid*; ſo will *London* bear N. ¾ E. from *Madrid*.
6. Let all the ſame be done for *Boſton*; ſo will *London* bear N. E. ½ E. from *Boſton*.

Note 1. The ſeveral Bearings in the ſeveral Problems aforementioned, muſt be underſtood, not as they really are ſo by the Compaſs on the terraqueous Globe, but according to ſo many Angles of Poſition, as each Place makes with the Meridian of that Place it bears from.

2. The bearing of one Place from another, by an Angle of Poſition, is extremely different from that of bearing by the Compaſs; and this will appear very evidently by making the Obſervation at *London*, to find all thoſe Places that lie Eaſt of it, both by the Angle of Poſition, and by the Compaſs.

Elevate the Pole to the Latitude of *London*, and bring *London* to the Meridian; then lay the Quadrant of Altitude from thence to the Eaſt-point of the Horizon, and the graduated Edge will run thro' *Holland*, between *Hungaria* and *Polonia*, thro' the Eaſtern Part of *Pontus Euxinus*, *Perſia*, *Mare Arabicum*, and the Iſle of *Ceylon*: But all theſe Places bear Eaſt of *London*, no otherwiſe than according to the Angle of Poſition, which they make with the Meridian of that Place. Whereas was a Ship to ſail Eaſt from *London*, by the Compaſs, ſhe muſt keep all along upon the ſame Parallel of Latitude with that of *London*, by which means the North-point of the Compaſs, and the Needle will always be together, allowing for the Variation all the Way.

3. If two Places are ſituated under the Line, *i. e.* the Equator; whatever their Diſtance is, they will be directly Eaſt and Weſt of each other, both by the Compaſs, and by an Angle of Poſition alſo. But,

4. If they be on the ſame Parallel any where elſe, tho' they are Eaſt and Weſt of each other, by the Compaſs, they will not be ſo by an Angle of Poſition, but deviate from that Rule, and ſo much the more, by how much the more diſtant thoſe Places are. Thus, let two Places be choſen at Pleaſure, which mark with Chalk, in 30° N. Lat. whoſe Difference of Long. is 40°; by the Compaſs, they will be Eaſt and Weſt of each other, but by an Angle of Poſition, between the two Places, the Eaſtermoſt Place will bear E. by N. of the Weſtermoſt; and the Weſtermoſt will bear W. by N. of the Eaſtermoſt. Keep the ſame Parallel of Latitude, and mark two Places, whoſe Difference of Long. ſhall be 80°, and then ſuch two Places, tho' Eaſt and Weſt of each other, by the Compaſs, as before, will now, by an Angle of Poſition, bear, the Eaſtermoſt, E. N. E. of the Weſtermoſt, and the Weſtermoſt bear W. N. W. of the Eaſtermoſt.

5. If two Places be choſen in 50° N. Lat. whoſe Difference of Long. is 40°, ſuch two Places will bear Eaſt and Weſt of each other, by the Compaſs; but not ſo by an Angle of Poſition; for the Eaſtermoſt, in this Caſe, will bear E. N. E. ½ E. of the Weſtermoſt, and the Weſtermoſt will bear W. N. W. ½ W. of the Eaſtermoſt. If the Difference of Long. between the two given Places be 80° in the ſame Latitude; or, which is the ſame thing, the Diſtance between the given Places be doubled, they will in this Caſe alſo be Eaſt and Weſt of each other, by the Compaſs, but not ſo by an Angle of Poſition; for now the Eaſtermoſt will bear N. E. by E. of the Weſtermoſt, and the Weſtermoſt will bear N. W. by W. of the Eaſtermoſt. Thus it is very plain, that in every Latitude, any two Places, on the ſame Parallel, will always lie Eaſt and Weſt of each other, by the Compaſs, but, the Bearing between the ſame two Places, by an Angle of Poſition, differs from a Bearing by the Compaſs widely; and not only ſo, but in every Change of Latitude, thoſe Angles of Poſition, differ from one another alſo, when compared, either by themſelves, or with the Bearings, by the Compaſs; and this I think is very eaſily accounted for, in the following Manner.

The North and South Points are fixed and determinate; all Meridians meeting there; and every Meridian, dividing the Globe into equal Parts; but it is not ſo with the Eaſt and Weſt Points, they being fixed no where. Now, as all Parallels of Latitude, are ſmall Circles, and thoſe Circles perpetually diminiſhing, the nearer they are to either of the Poles, it is impoſſible for them to interſect one another, as the Meridians do; and therefore, notwithſtanding, that every Parallel runs due Eaſt and Weſt, there can be no particular Eaſt and Weſt Points, as there are North and South. Hence any two Places, that bear Eaſt and Weſt of each other, by the Compaſs, are upon a Parallel of Latitude, and conſequently are ſituated on the Arch of a ſmall Circle; but if the Bearing of the ſame, or any other two Places, be required by an Angle of Poſition, thoſe two Places are then found to be ſituated on the Arch of a great Circle, which divides the Globe into two equal Parts; and therefore, any two Places, conſidered firſt, as being on the Arch of a ſmall Circle, and ſecondly, as being on the Arch of a great Circle, muſt differ in their Manner of bearing from each other, under ſuch different Circumſtances.

6. If the given Places lie under the ſame Meridian, they will bear directly North and South of each other, by the Compaſs, whatever their Diſtance be, and for that Reaſon there can be no Angle of Poſition. But,

7. If the given Places lie obliquely, in any Reſpect, as *London* and *Rome*, tho' they be oppoſite to each other, with regard to the Compaſs; *London*, lying N. W. by N. ¾ W. of *Rome*; and *Rome*, lying S.E. by S. ¾ E. of *London*; yet by two Angles of Poſition, made by bringing each Place to the Zenith, they will be found to bear from each other in another Manner. *Vide*, *Prob*. LVI.

8. By Mercator's plane Chart, two Places are always oppoſite; *i. e.* if one Place is N. E. of *London*, then *London* is S.W. of that; but upon the Globe, by the Quadrant of Altitude, it is not ſo.

☞ I have been the longer on this Subject, becauſe a certain Writer, among his ſeveral Productions, has given us one on the *Globes*; and there in *Prob* .XXIX. p. 159, gives a Bearing; but makes no Diſtinction beween the Bearing, by an Angle of Poſition, and a Bearing by the Compaſs: and therefore, the Learner, by his Book, will be apt to underſtand, that ſuch Bearing muſt be according to the Compaſs, which is abſolutely falſe; for all the Bearings given by him, in that *Problem*, are only ſo many Angles of Poſition. What an Angle of Poſition is, he has no where mentioned, for the Inſtruction of his *dear Pupil*; and by ſuch an Omiſſion, I am inclined to think (tho' I will not affirm it to be ſo) that he took them both for one and the ſame thing. A Miſtake as great, or worſe, the ſame *Gentleman* has made about the *Dog-days*; of which more in its proper Place. Indeed the whole Book, is almoſt one continued Error; I dont mean Typographical ones, tho' there are but too many of them, but Rules and Examples without being properly diſtinguiſhed, falſe Grammar in ſeveral Places, and bad Method every where; and, where he mentions ſome Stars, as Parts of ſome particular Conſtellation, he calls, one *Cor Scorpio*, another *Cor Hydra*, and a third *Pes Centaurus*; by which, it appears, he knew not how to form the Genitive Caſe, by the Syntactical Rule, *Quum duo Subſtantiva diverſarum rerum*, &c. and when inform'd of it, by way of Letter, was weak enough to ſay, *Firſt Editions are excus'd*; but all thoſe Faults happened in the *Second Edition*, which I ſhould not have mentioned, but on the Account of a ſcornful Freedom with my Name, which that *Gentleman* had unjuſtly taken.

PROBLEM LIX.

The Day of the Month being given, to find what other Day of the Year, will be of the ſame Length.

Given, *Sept. 20th.*

Required, what other Day is of the ſame Length.

Note, Place and Latitude are here out of the Queſtion.

1. Find the Sun's Place in the Ecliptic for the given Day, and mark it on the Globe.
2. Bring it to the Meridian, and make a mark over it, which is the Sun's Declination for the given Day.
3. Turn the Globe, till ſome other Degree of the Ecliptic comes under that Mark on the Meridian, which is the Sun's Place for the Day required, *viz.* 3° ♈.
4. Obſerve on the wooden Horizon, or by an Ephemeris, what Day anſwers to the Sun's Place thus found, which is the Day required, *viz. March 23d.* both being (for the Latitude of *London*) 12 *hrs.* 17 *min.* long, as will appear, by *Problem* XVIII.

Note, This *Problem* will hold good in all Latitudes, both N. and S. but with this Difference, that the Length of the Days themſelves will be greater or leſs in one Latitude than in another.

PROBLEM LX.

The Latitude of a Place, and Day of the Month being given, to know at what Hours of that Day, the Sun will be due Eaſt and Weſt, within the Compaſs of the Horizon.

Note, This, in any North Latitude, can happen only when the Sun is upon the Equinoctial, or ſomewhere Northward of it.

Given, *London*, in Lat. 51° 32′ N. and *April 27th.*

Required, the ſeveral Hours of that Day, when the Sun will be due Eaſt and Weſt.

1. Rectify the Globe for the given Latitude.
2. Find the Sun's Place in the Ecliptic for the given Day, and mark it on the Globe.

3. Bring the Sun's Place to the Meridian, and fix the Globe.

4. Turn the Index to Noon.

5. Fix the Quadrant of Altitude in the Zenith.

6. Bring the Quadrant to the Eaſt Point of the Horizon, and there keep it ſteady.

7. Turn the Globe, till the Sun's Place touches the graduated Edge of the Quadrant.

8. Obſerve the Hour pointed at, by the Index on the horary Circle, *viz.* 6 *hrs.* 37 *min.* A. M. at which Time the Sun is due Eaſt.

9. Bring the Quadrant to the Weſt Point of the Horizon, and there keep it ſteady.

10. Turn the Globe, till the Sun's Place touches the graduated Edge of the Quadrant.

11. Obſerve the Hour pointed at, by the Index on the horary Circle, *viz.* 5 *hrs.* 7 *min.* P. M. at which Time the Sun is due Weſt.

Note, When the Sun is South of the Equator, his Eaſting and Weſting are below the Horizon of the given Place, and there ore cannot be determined by the Quadrant of Altitude in the aforeſaid Poſition of the Globe, becauſe the Sun's Place will be ſo remote, as not to meet it; in ſuch Caſe, therefore the South Pole muſt be elevated to the given Latitude, and then proceed as hereafter,

Given, *London*, in Lat. 51° 32′ N. and *Nov.* 30;
Required, the Hours of the Day and Night, when the Sun, being below the Horizon, will be due Eaſt and Weſt.

1. Elevate the South Pole to the given Latitude.

2. Bring the Sun's Place to the Meridian, and fix the Globe.

3. Turn the Index, at the North Pole, to that XII, which would be Noon, if the North Pole was elevated.

4. Fix the Quadrant of Altitude in the Zenith.

5. Bring the Quadrant to the Eaſt Point of the Horizon, and there keep it ſteady.

6. Turn the Globe, till the Sun's Place touches the graduated Edge of the Quadrant.

7. Obſerve the Hour pointed at, by the Index, *viz.* 7 *hrs.* 15 *min.* the Complement, whereof to XII, is 4 *hrs.* 45 *min.* A. M. at which Time the Sun is due Eaſt of *London*.

8. Bring the Quadrant to the Weſt Point of the Horizon, and there keep it ſteady.

9. Turn the Globe, till the Sun's Place touches the graduated Edge of the Quadrant.

10. Obſerve the Hour pointed at by the Index, *viz.* 4 *hrs.* 50 *min.* the Complement, whereof is 7 *hrs.* 10 *min.* P. M. at which Time, the Sun is due Weſt of *London*.

Note, If the Globe be kept in its proper Poſition, with the North Pole elevated; a long Wire might be made to ſupply the want of the Quadrant of Altitude, or a double one might be made, if approved of, and then the Sun's Place being brought to meet with it beneath the Horizon, both for Eaſt and Weſt, will ſhew the reſpective Hours, of Morning and Evening, for the Sun's Eaſting and Weſting, as before.

PROBLEM LXI.

Any Parallel of Latitude being given, to find how many Miles make a Degree of Longitude in that Parallel.

Given, the Parallel of Lat. in 51° 32′ N.
Required, the Number of Miles, that make a Degree of Longitude, in that Parallel.

1. With ſome pliant Zone, or Part thereof, made of ſmall Wire, take off any Number of Degrees (ſuppoſe 20) from the given Parallel.

Note, As there is no parallel Line drawn on the Globe for the given Latitude, it is very eaſy to make one, by applying a ſmall Piece of Chalk, or black lead Pencil, finely pointed, to the given Latitude on the Meridian, and then turning the Globe about, till ſo much of a Circle is made, as will be equal to 20 Degrees in that Latitude.

2. Apply that Diſtance to the Equator, and obſerve how many Degrees it makes there, *viz.* 12° ½.

3. Obſerve the following Proportion; *viz.*

As 20° on the Equator :
Are to 12° ½ in the Lat. of 51° 32′ : :
So is one Degree on the Equator :
To the Number of Minutes, equal to a Degree in the given Latitude.

```
 °      °        °
20 : 12.5 : : 1
             60
    ——————
20) 750.0 (37.5 Miles.
```

But for exactneſs, uſe the following Proportion.

As Radius - - - - - - - - 10.0000000

To the Sine Comp. of 51° 32′ - 9.7938317
So is 60 - - - - - - - - - 1.7781513

To 37.323 + - - - - - - - - 1.5719830

4. The Anſwer (by the Globe) is 37 Miles and a half go to a Degree in the Lat. of 51° 32′.

Note 1. The Table of Longitudinal Miles to the ſeveral Degrees of Latitude, in p. 14, may be thus framed by the Learner; tho' not ſo exactly, as by the Trigonometrical Canon abovementioned.

2. The Gentleman, whom I mentioned a little before, recommends two Ways to take off any Number of Longitudinal Degrees on a ſmall Circle, in the Latitude of 52° and then apply them to the Equator to ſee what they make. And,

The firſt is the Quadrant of Altitude: But that will not do, becauſe a Circle in that Latitude curves too much, and the Quadrant of Altitude will meaſure no Arch, but that of a great Circle.

The ſecond Way is, to take any Number of Degrees, by a Pair of *good Dividers* (as he calls them) but in this Caſe, the *beſt Dividers* will not do, becauſe the Diſtance ſo taken is the Chord of that Arch, and not the Arch itſelf; and when that is applied to the Equator, will not reach ſo far as it ought; and the greater the Number of Degrees ſo taken and applied, the greater will the Error be. Tho', he ſays, take 10° in the Parallel of Latitude 52°, and apply that Diſtance to the Equator, and it will cut 6° ⅙; but I found by trying with Wire, as aforeſaid, that it will make 6° ¼: And therefore to ſhew the Error of his Method, I made trial by Dividers, from 10° to 90° (in that Latitude or Parallel) as hereafter; and I ſuppoſe my Globes are none of the worſt.

10 : 6,25

10 : 6.25 : : 1 : 37.5
20 : 12. 5 : : 1 : 37.5
30 : 18. 5 : : 1 : 37.0
40 : 24. 5 : : 1 : 36.75
50 : 30. 5 : : 1 : 36.6
60 : 35. 5 : : 1 : 36.333+
70 : 41. 2 : : 1 : 35.314+
80 : 46. 5 : : 1 : 34.875
90 : 51. 5 : : 1 : 34 333+

Thus it appears, very evidently, that by increaſing the Number of Longitudinal Degrees, the Error increaſes alſo.

I next made trial, by a Wire properly bent, at once to 90° Longitudinally on the Parallel of 52°, and then applied that Length to the Equator, and it reached to 55.5 : hence the following Proportion.

°   °   °   °
90 : 55.5 : : 1 : 37 Miles.

BY TRIGONOMETRY.

As Radius - - - - - - 10.0000000

To Sine Comp. of 52° - 9.7893420
So is 60 - - - - - - - 1.7781513

To 36.939+ - - - - 1.5674933

Thus the two Methods agree, almoſt to an exactneſs ; but the Canon is only to be depended on.

PROBLEM LXII.

The longeſt Day in any Latitude being given, to find in what other Latitude the longeſt Day is one, two, three, or more Hours, or any other given Time, longer or ſhorter, than the Day given.

1. *Longer.*

Given, *London*, in Latitude 51° 32′ N. whoſe longeſt Day is 16 *hrs.* 30 *min.*

Required, that Latitude, whoſe longeſt Day is juſt 18 Hours : *i. e.* 1 *hr.* 30 *min.* longer than the given Day.

Note, For every Hour added to or deducted from the given Time, 7° ½, on the Equator, muſt paſs under the Meridian ; and ſo on in Proportion, for a ſmaller or larger Quantity of Time.

1. Rectify the Globe for the given Latitude.

2. Bring the firſt Degree of ♋, or the Solſtitial Colure, which makes the longeſt Day at the given Place, to the Meridian, and fix the Globe.

3. Obſerve where the Eaſtern Side of the Horizon cuts the Tropic of ♋, and make a Mark there.

4. Turn the Globe Weſtward, till 11° ¼ of the Equator paſs under the Meridian (they being equal to 1 *hr.* 30 *min.* abovementioned) and fix the Globe again.

5. Make a ſecond Mark on the ſaid Tropic, againſt the ſame Eaſtern Side of the Horizon, as before.

6. Bring the firſt Degree of ♋ to the Meridian again, and fix the Globe with a Quill between it and the Meridian.

7. Elevate the Pole, till the ſecond Mark appears at the Edge of the Horizon.

8. Obſerve where the Horizon cuts the Meridian; for that is the Latitude required, *viz.* 58° ½.

> *Note,* The like Marks may be made on the ſaid Tropic on the Weſtern Side of the Horizon; only before the ſecond Mark is made, you muſt turn the Globe Eaſtward.

2. *Shorter.*

Given, *London,* &c. as before.

Required, that Latitude, whoſe longeſt Day is juſt 14 *hrs.* 30 *min.* *i. e.* 2 *hrs* ſhorter than the given Day.

1, 2, 3, as before.

4. Turn the Globe Eaſtward, till 15° of the Equator paſs the Meridian.

5. 6, as before.

7 Depreſs the Pole, till the ſecond Mark meet the Edge of the Horizon.

8. Obſerve where the Horizon cuts the Meridian; for that is the Latitude required; *viz* 35° ½.

> *Note,* The like Marks may be made on the ſaid Tropic on the Weſtern Side of the Horizon; only before the ſecond Mark is made, turn the Globe Weſtward.

PROBLEM LXIII.

The Latitude of a Place, and Day of the Month being given, to find how much the Sun's Declination muſt increaſe or decreaſe, to make the artificial Day an Hour longer or ſhorter than the given Day; alſo to find the Sun's Place at that Time, and the Number of Days between the lengthening or ſhortening from the given Day.

1. For the lengthening.

Given, *London,* in Lat. 51° 32′ N. and *Feb.* 24.

Required, the Number of Degrees the Sun muſt decline Northward, to make the Day one Hour longer; alſo the Sun's Place at that Time, and the Number of Days that happen between.

1. Elevate the North Pole to the given Latitude.

2. Find the Sun's Place in the Ecliptic for the given Day, and mark it on the Globe.

3. Bring the Sun's Place to the Horizon, and where it coincides make a Mark.

4. Bring either of the Colures to the Horizon, and where ſuch Colure coincides with the Mark on the Horizon, on that Colure make a Mark alſo.

Note, Any other Meridian will anſwer the ſame End, as well as the Colures.

5. Move the Globe Eaſtward, becauſe of the increaſe, till 7° ½ on the Equator paſs the Meridian.

6. Then make another Mark on the ſame Colure, where it interſects the Horizon.

7. Bring that Colure to the Braſs Meridian, and obſerve what Number of Degrees are contained between the two Marks, *viz*. 6°, which is the Declination Northward to make the Day one Hour longer.

8. Make a Mark on the Meridian directly over the laſt Mark on the Colure.

9. Obſerve what Part of the Ecliptic will paſs under that Mark on the Meridian, which is the Sun's Place for the lengthened Time, *viz*. 20° ♓.

Note, It muſt be that Part of the Ecliptic, which is on the Weſtern Side of the ſolſtitial Colure, becauſe the Days are lengthening.

10. Look on the Horizon for the Sun's Place, laſt found, and againſt it is the Day of the Month, *viz*. *March* 11*th*, for the lengthened Time.

11. Reckon the Number of Days between the firſt and laſt Days (incluſive) and they will be the Time required for the lengthening of the Day an Hour from the given Day, *viz*. 16 Days.

2. *For the ſhortening.*

Given, *London*, in Lat. 51° 32′ N. and *July* 26.

Required, the Number of Degrees the Sun muſt decline Southward to make the Day an Hour ſhorter; alſo the Sun's Place at that Time, and the Number of Days that ſhall happen between.

1, 2, 3, 4, as before.

5. Turn the Globe *Weſtward*, becauſe of the Decreaſe, till 7° ½ on the Equator paſs the Meridian.

6. As before.

7. Bring the Colure to the Meridian, and obſerve what Number of Degrees are contained between the two Marks, *viz*. 4° which is the Declination Southward to make the Day an Hour ſhorter.

8. As before.

9. Obſerve what Part of the Ecliptic will paſs under that Mark on the Meridian, which is the Sun's Place for the ſhortened Time, *viz*. 19° in ♌.

Note, It muſt be that Part of the Ecliptic which is on the Eaſtern Side of the ſolſtitial Colnre, becauſe the Days are ſhortening.

10. Look on the Horizon for the Sun's Place laſt found, and againſt it is the Day of the Month, *viz*. *Aug*. 12*th*, for the ſhortened Time.

11. Reckon the Number of Days, between the firſt and laſt Days (incluſive) which will be the Time required for ſhortening the Day, an Hour, from the given Day, *viz*. 18 Days.

Note, By working this Problem for different Times of the Year, it will readily ſhew, that the Days are not lengthened or ſhortened an Hour every 15 Days: For when the Sun is near either of the Equinoctial Points, the Days lengthen or ſhorten apace, becauſe there, the Ecliptic is very oblique to the Equator; but when he is near either of the Tropical Points or Solſtices, then they lengthen or ſhorten very ſlowly; becauſe there the Ecliptic runs nearly Parallel to the Equator.

PROBLEM LXIV.

The North Pole being given, to find how long it continues to be Twilight, after Sun-ſet; and how long their Night is after Twilight ends, before that Twilight begins again.

Given, the North Pole, or 90° in North Latitude;
Required, the Length of Twilight after Sun-ſet, and the Length of Night after Twilight ends, before Twilight begins again.

Note 1. The Sun ſets with the Inhabitants of the North Pole (if there be any) on the 22*d.* of *Sept.* when he enters the firſt Degree of ♎.

2. Immediately after Sun-ſet, Twilight begins, and continues till the Sun is 18° below the Horizon. See Problem XXXV.

1. Bring the North Pole to the Zenith.

2. Turn the Globe about, till that Part of the Ecliptic following Sun-ſet, or the firſt Degree of ♎ falls directly under 18° of the Meridian in South Declination, which will be 20° in ♏, which is the Sun's Place for the 12*th* Day of *November*; and therefore for ſo long Time as from *Sept.* 22*d*, to *Nov.* 12*th*, will Twilight continue.

3. Turn the Globe, till another Point of the Ecliptic meet the ſame 18° South Declination, which will be 10° ♒, which is the Sun's Place for *Jan.* 29*th*, (during all which Time it will be dark Night under the North Pole;) at which Time, Twilight begins again, and holds till *Mar.* 21*ſt*, when the Sun enters the firſt Degree of ♈, and then is riſing at the given Pole.

Note 1. When the Sun croſſes the Equator, there is an horizontal Refraction to the Polarians; they will therefore ſee the apparent Sun for ſo long Time after he really departs from the Equator, and before he re-approaches the ſame, as he is tranſiting a Quantity of Declination, equal to the horizontal Refraction; and what that is, Tables of the ſame will ſhew. But it is nevertheleſs to be obſerved, that at ſundry Places in the Northern Regions, the horizontal Refraction has been found greater, than the Tables ſhew very conſiderably. It is ſaid that the Dutch, in *Nova Zembla*, have ſeen the Sun, when he ought to have been depreſs'd four Degrees below the Horizon. *Vid. Hodgſon's Syſt.* Vol. II. page 274.

2. From this Problem it appears, that the Inhabitants at the North Pole, have no leſs than 52 Days Twilight, or rather ſuch a Length of Time as is adequate thereto; and therefore ſome might aſk how it comes to paſs, that there is ſo much Twilight at the North Pole, and not above 1 *hr.* 12 *min.* at the Equator, during the Sun's paſſage 18° below the Horizon? To which it may be anſwered.

(1.) That when the Sun ſets with the Inhabitants at the Equator, he goes right down; and as 15° on the Equator, make 1 Hour of Time, and 3° make 12 Minutes; ſo the Quantity of Time allow'd for Twilight can be no more than 1 *hr.* 12 *min.* it being there a direct Sphere.

(2.) In any Place between the Equator and the North Pole, it makes an oblique Sphere, and the nearer any Place is to the North Pole the greater is the obliquity: conſequently as the Sun ſets in ſuch a Latitude, not downright but ſlanting, it muſt take up more Time before the Sun gets 18° below the Horizon.

(3.) From the Sun's obliquity, being the greater, the nearer the approach is to the North Pole, it muſt follow that at the Pole itſelf, the obliquity is ſo great as to make all the Parallels of Latitude become Parallel to the Horizon: Hence, as the paſſage of the Sun is nearly circular under the Pole; he moves in ſuch ſmall ſpirals as almoſt approach to a Parallel with the Horizon: And therefore, as the Sun is ſo long as from *Sept.* 22*d.* to *Nov.* 14*th.* before he gets 18° below the Horizon, there muſt be ſo long Twilight.

(4.) What is ſaid concerning Twilight at the North Pole, holds good at the South Pole alſo.

(5.) In the ſame Point, *viz.* ♎ that the Sun ſets at the North Pole, he riſes at the South Pole: And when the Sun riſes in ♈ at the North Pole, he ſets in the ſame Point at the South Pole.

PROBLEM LXV.

The Latitude of a Place in the Torrid Zone, and Sun's Declination being given, to find thoſe particular Times of the Day, when the Sun will be twice in the Forenoon, and twice in the Afternoon, upon the ſame Azimuth or Point of the Compaſs.

Note 1. This happens only when the Declination of the Sun exceeds the Latitude of the Place given; and therefore muſt be ſomewhere in the Torrid Zone.

2. The Declination and Latitude muſt be both on the ſame Side of the Equator; *i. e.* both North, or both South.

3. The more the Declination exceeds the Latitude, the more conſpicuous is this curious *Phenomenon*.

Given, *Barbadoes*, in Lat 13° N. and the Sun's Declination 20° N. Required, the Times of the Sun's appearing on the ſame Azimuth twice in the Morning, and twice in the Afternoon.

1. *For the Morning*.

1. Rectify the Globe for the Latitude of *Barbadoes*.

2. Mark the Sun's Declination on the Meridian.

3. Turn the Globe, till ſome Part of the Ecliptic (on either Side of the Summer Solſtice, no matter which) coincides with the Declination; one of which, in this Caſe, is the beginning of ♊, and is the Sun's Place for that Declination, which mark on the Globe.

4. Fix the Globe.

5. Put the Index of the horary Circle to Noon.

6. Fix the Quadrant of Altitude in the Zenith.

7. Bring the Sun's Place to the Eaſtern Horizon, and fix the Globe again.

8. Obſerve the Index, and you will find the Time to be 5 *hrs.* and almoſt 3 *qrs.* which is the Time of the Sun's riſing for that Declination and Latitude.

9. Bring the Quadrant of Altitude to meet the Sun's Place, and then the Sun's Azimuth will be E. N. E. and about half a Quarter E. or 69°, from the Meridian; its ortive Amplitude, at the ſame Time being 21° Northward of the Eaſt.

10. Keep the Quadrant with the Sun, and turn the Globe Weſtward, and the Sun's Azimuth will be continually inclining towards the Eaſt, till the Azimuth be within 16° of the Eaſt, which is the Sun's greateſt Azimuth, or fartheſt it will then go, and the Sun be advanced about 34°.

11. Move the Globe ſtill Weſtward, till the Sun has advanced about 12° more, *viz.* 46° in all, and from 34° to 46° the Sun (with regard to the Azimuth) will appear to be Stationary; *i. e.* on the ſame Azimuth, or very nearly ſo.

12. Move the Globe ſtill Weſtward, and then the Sun's Azimuth will be perpetually declining from the Eaſt towards the North, and about half an Hour after Ten, A. M. the Sun will be about 68° high, and upon the ſame Azimuth as at its Riſing; *viz.* E. N. E. half a Quarter Eaſt.

2. *For the Afternoon.*

1, 2, 3, 4, as before.

5. The Sun's Azimuth at his Setting, will be juſt as many Degrees from the North, Weſtward, as it was at his Riſing from the North, Eaſtward; *viz.* 69°. or W. N. W. and about half a quarter Weſt, its occaſive Amplitude being then 21° Northward of the Weſt; therefore bring the Quadrant of Altitude to the laſt mentioned Azimuth, or Azimuth at Sun-ſet, and there keep it ſteady.

6. Move the Globe Weſtward, and at half an Hour after One, or nearly ſo, P. M. the Sun will be upon the ſame Azimuth as at its Setting, being then about 68° high.

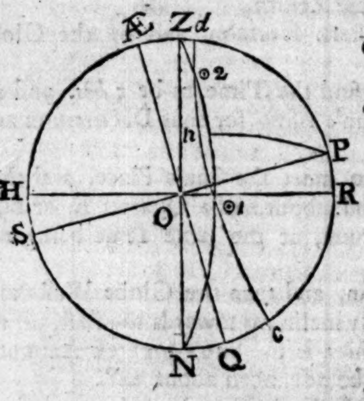
7. Keep the Quadrant on the Sun's Place, and turn the Globe Weſtward, and its Azimuth will be continually inclining towards the Weſt, till the Azimuth be within 16° of the Weſt, which is the fartheſt it will then go, and the Sun be about 46° high.

8. Move the Globe ſtill Weſtward, till the Sun has fallen about 12°, and from 46° to 34° the Sun will appear to be Stationary, *i. e.* on the ſame Azimuth, or very nearly ſo.

9. Move the Globe ſtill Weſtward, and then the Azimuth will be perpetually declining from the Weſt towards the North, till at its Setting, it comes to the ſame Azimuth, as it was at half an Hour after One; *i. e.* W. N. W. half a quarter W.

See the foregoing Problem, wrought Aſtronomically, as under.

EXPLICATION of the FIGURE.



ÆZPRQNSH, the Meridian of *Barbadoes*.

Z, the Zenith; N the Nadir of *Barbadoes*.

HOR, the Horizon of *Barbadoes*.

POS, the Axis, and P the North Pole elevated to the Lat. of *Barbadoes*.

ÆOQ, the Equator.

Æ *d* = Q *c* = the Sun's Declination = 20°.

1 ⊙, the Sun's Place at riſing in the Horizon HOR.

d ⊙ ⊙ *c*, the Parallel of the Sun's Declination.

Z⊙ ⊙N, the Azimuth or Vertical Circle, paſſing thro' the Sun in two Places, in ⊙ 1 and ⊙ 2, both A.M. and P.M.

1 ⊙ Q, the Sun's Amplitude.

2 ⊙, the Sun's Place on the ſame Azimuth, as at his Riſing, and the ſame, which will be made on the Weſtern Side, towards Setting. The Inhabitants of *Barbadoes*, at Z, will ſee the Sun move in the Parallel of Declination ⊙ 1, ⊙ 2, *d* uniformly, and from ⊙ 1, at Riſing it inclines more and more towards the Eaſt, until it arrives at the Perpendicular P *n*,

when it inclines again towards the North, until it arrives at ⊙ 2, in the ſame Vertical Circle, from whence it moves almoſt Parallel to the prime Vertical ZN, until it arrives at the Meridian *d*, and then makes its return in like Manner to the Weſtward, as before, and thus this curious Phenominon is finiſhed for one Day: the next being a Repetition; and ſo on for ſeveral Days together, while the Latitude of the Place is leſs than the Sun's Declination, and both the ſame Way.

Note 1. It will be agreeably ſurpriſing to obſerve (by keeping the Quadrant of Altitude on the Sun's Place as the Globe is moved) how ſwiftly the Azimuths change to and from the Meridian, which is North, till the Sun comes to the ſame Azimuth as at its Setting.

2. The ſame Phenomenon will appear upon that whole Parallel, in all its Circumſtances, juſt as it appears at Barbadoes, at the given Declination.

PROBLEM LXVI.

To hang a Globe in ſuch manner, that when the Sun ſhines upon it, it will demonſtrate ſeveral inſtructive Principles, both in *Aſtronomy* and *Geography*.

1. Take the Globe out of the Horizon.
2. Tie a Thread to the Brazen Meridian.
3. Bring the Thread to the Latitude of any given Place, and ſuſpend it in a ſmall Frame.
4. Place it in ſuch Manner, that the Sun may ſhine freely upon it.
5. Direct the Poles to their proper Places in the Heavens, and keep them in that Poſition.
6. Bring the given Place to the Meridian, and fix the Globe.—Thus the Globe will correſpond in all Reſpects with the Earth itſelf: the Poles and Meridian of the Globe will anſwer to the Poles and Meridian of the World, according to the given Place and its Latitude; and the ſeveral Quarters and Regions will exactly anſwer the real Quarters and Regions on the Earth, which thoſe on the Globe repreſent. And,

I. While the Sun ſhines upon the Globe, one Hemiſphere will be enlightened, and the other will be ſhadowed, which at one View diſcovers Day and Night, over the Face of the whole Earth. All thoſe Places ſituated within the enlighten Hemiſphere enjoying Day, while the ſhadowed Part or Hemiſphere diſcovers Night to all thoſe Places that are within it.

II. If a Needle be placed perpendicular in the middle of the enlightened Hemiſphere, which muſt be on the Sun's Place in the Ecliptic, or on the ſame Parallel with it, it will project no Shadow at all, but ſhews that the Sun is vertical, directly over, or in the Zenith of that particular Place, where the Needle is fixed, which being brought to the Meridian, ſhews the Sun's Declination from the Equinoctial, either Northward or Southward for that Day.

III. If a Thread be brought from one Pole to the other, directly over that Place where the Needle was fixed, it will ſerve for a Meridian Line, under which all Places, ſo found, have their Noon at that Time: All Places to the Weſt of the ſaid Line have Morning, and all Places to the Eaſt of it have Afternoon or Evening.

IV. Obſerve, on the Equator, that particular Degree, which is the Medium between Light and Darkneſs; for ſo many Degrees as are found between that Degree and the Meridian of any Place converted into Hours, at 15° to an Hour, ſhew, if the Sun be Eaſtward of that Place, how long it will be before the Sun-riſes, ſets, or comes to the Meridian of that Place; or if the Sun be Weſtward of it, how long it is ſince the Sun roſe, ſet, or came to the Meridian of the ſame Place.

V. The Inhabitants of all Places between Light and Darkneſs, quite round the Globe, ſee the Sun in their ſeveral Horizons, but with this Difference; thoſe who are Weſtward of the Meridian Semicircle, made by the Thread (aforementioned) laid from Pole to Pole, through the middle of the enlightened Hemiſphere, behold the Sun-riſing, while thoſe on the Eaſt-ſide obſerve it ſetting; thoſe on the North-part will juſt ſee the Sun tranſit their Meridian ſoutherly, and thoſe on the South-part will obſerve the ſame northerly.

VI. If the Sun's Declination ſhould be Northward, at the Time of Obſervation, it will ſhine beyond the North Pole; and ſo many Degrees as it reaches beyond the ſaid Pole, ſo many Degrees is the Declination of the Sun North.

VII. If a Circle be deſcribed at the Termination of the Sun-ſhine about the North Pole; then all thoſe Places included within that Circle, enjoy perpetual Day, till the Sun's Declination becomes leſs, than it is at that particular Time; *i. e.* inclines more towards the Equator; for the Sun goes not below their Horizon, as may be ſeen by turning the Globe about its Axis: And in the oppoſite Pole, at the ſame Diſtance, the Sun-ſhine not reaching thither, it will be always Night, till the Sun gets back again into the Equinoctial.

VIII. If the Globe hangs very ſteady, it will be very agreeable to obſerve, on the Eaſt-ſide of it, when the Sun is Weſtward of the Meridian, how by little and little the Sun departs from any Place, and cauſes Night to follow it; and on the Weſt ſide, when the Sun is Eaſtward of the Meridian, it is alſo as agreeable to obſerve how, by ſmall Encroachments, the Sun advances, and brings deſirable Day.

IX. If a narrow Girdle be made of Paper, or Parchment, to circumſcribe the Globe juſt on the Equator, and be divided into 24 equal Parts, to repreſent the 12 Hours of Day, and 12 Hours of Night, as at *Problem* XXII. and one of the XII's be placed on the Equinoctial, under the Meridian of the given Place, you will have a Sun-dial, and the Hour of the Day given on it in two Places at once; that is, on the Eaſtern and Weſtern Sides of the enlightened Hemiſphere, juſt in the Medium, between Light and Darkneſs.

X. The horary Circle, the Index being taken off, exhibits another Sundial; the Polar Wire ſerving for a Gnomon or Style, the Shadow of which is caſt on the Hour of the Day; on the Weſtern Side for Morning, the Sun being Eaſtward of the Meridian of the given Place; and on the Eaſtern Side for Afternoon, the Sun being then Weſtward of the Meridian of the given Place. See *Problem* XXII. aforegoing.

PROBLEM LXVII.

Of the Harveſt-Moon.

This is the Moon, whoſe Full, happens either upon the Autumnal Equinox, or near it, whether before or after it: And a few Nights before the Full, and alſo a few Nights after it, ſhe riſes nearly at the ſame Hour; that is, within a ſhort Time before and after the ſetting of the Sun; by which Phenomena or Appearances, the whole Hemiſphere becomes enlightened, firſt by the Sun, and then by the Moon, which not only makes the Nights pleaſant, but in ſome Reſpects profitable alſo, for the enabling the Farmers to get in their Corn-harveſt, hence called the Harveſt-Moon: And becauſe the Seaſon for Hunting happens about this Time, it is called the Hunters Moon: And alſo becauſe Shepherds, for the better Management of their Flocks, are content to lie abroad on thoſe Nights; it is called the Shepherds Moon.

It is much to the preſent Purpoſe, to have ſuch a Year as had the Full Moon on the Autumnal Equinox; and it is ſomething remarkable, that this Full Moon happened on the 23*d.* Day of *Sept.* 1752, when the New-Stile took Place in Oppoſition to the old or erroneous Stile.

Now if the Places of the Sun and Moon for two or three Days before the Full, and two or three Days after the Full be produced, it will appear by the Globe, that the ſeveral Times of the Moon's riſing, on thoſe Days, were very near each other, tho' her Southing was all along, at about 48 Minutes (ſomething more or leſs) every Night later than the former.

Thus for the Month of *Sept.* 1752, the Sun's Place, Moon's Place, and Moon's Latitude, were as follows, *viz.*

		Sun's Place.			*Moon's Place.*			*Moon's Lat.*	
		°	'		°	'		°	'
Sept.	20	27	50	♍	22	18	♒	5	6 North.
	21	28	49		4	50	♓	4	51
	22	29	47		17	34		4	23
	23	0	46	♎	0	37	♈	3	41
	24	1	45		13	52		2	46
	25	2	44		27	21		1	39
	26	3	43		11	1	♉	0	27

Hence we may proceed as hereunder, *viz.*

Given, *London*, in Lat. 51° 32', the Days of the Month, Sun's Place, Moon's Place, and Latitude on thoſe Days, as above.

Required, the Time of the Moon's riſing on the ſame Days.

1. Rectify the Globe for the Latitude of *London.*
2. Bring the Sun's Place for each Day to the Meridian.
3. Set the Hour Index to the upper XII.
4. Find the Moon's Place in the Ecliptic, and her Latitude for each Day; and on her Latitude, make a Mark, or ſtick a ſmall Patch or Pin.
5. Bring that Mark, or Pin to the Eaſtern Side of the Horizon, and fix the Globe.
6. The Index will then ſhew the Hour of the Moon's riſing, for the ſeveral Days reſpectively, *viz.*

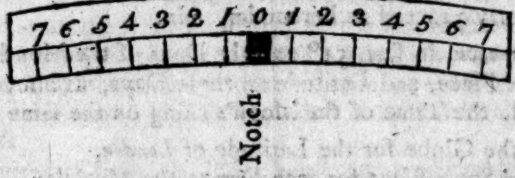
		Moon's riſing.	
		h.	m.
Sept.	20	4	46
	21	5	5
	22	5	52
	23	6	7
	24	6	13
	25	6	34
	26	7	16

Note, Some Globes have no Parallels of Celeſtial Latitude marked upon them within the Compaſs of the Zodiac; to ſupply their Want therefore, I have contrived an Inſtrument that will ſhew ſuch Latitude exactly.

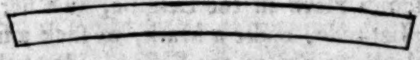
1. Draw, on a Piece of Paper, an Arch of a Circle of the ſame Curvature with the Globe, and one or two outer Arches from the ſame Center.
2. Between thoſe two (which at the Time of uſing, muſt be next the Globe) mark 7 or 8 Degrees (the ſame as on the Ecliptic) North and South, that the Zodiac is of the Ecliptic.
3. Take a ſmall Piece of Board, about $\frac{1}{10}$ of an Inch thick, and about four Inches long, nicely planed, on which, draw an Arch of a Circle, of the ſame Curvature with the Paper abovementioned, and then pare off that Part of it, cloſe to the Line, which is deſigned to be next to the Globe, and paſte the ſaid Paper upon it, ſo that the Arches of the Paper and Wood may be the ſame.
4. In the middle of this Board, *viz.* at 0, make a ſmall Notch, fit to receive another Piece of the ſame Curvature, and about $\frac{1}{10}$ of an Inch thick or ſquare, from End to End, and about 2 or 3 Inches long;
5. Incert this ſmall Piece into the larger Piece, Center to Center, and at right Angles with each other.
6. Both theſe together, make the Latitudinal Inſtrument for finding or laying down the Latitude of the Moon, or of any other Planet on the Globe.
7. To uſe it, lay the ſmaller Piece on the Ecliptic, and the longer Piece upon the given Sign and Degree of the Ecliptic, croſs wiſe or meridionally, ſo ſhall the Latitude of the Moon, or of any other Planet be put down upon the Globe very exactly.

The Nature and Size of the ſaid Inſtrument is thus repreſented, for a Globe of 16 Inches Diameter.

The larger Piece.



The ſmaller Piece.



Several Writers on the Uſes of the Globes, have given us their Aſtronomical Solutions of this curious Problem, but in ſo abſtruſe a Manner, that they are hard to be underſtood, by young Learner's: And altho' their

Solutions are true, yet there ſeems to be wanting a plainer one than any which hath hitherto been given; I ſhall, therefore, give the following, which I think is much eaſier, for Beginners eſpecially.

In every Year, about the Autumnal Equinox, the Moon, when near the Full, always riſes to the Southward of the Eaſt, but more and more towards the Eaſt, for ſeveral Nights together, till ſhe has paſſed that Point, and become Full; and then ſtill onward, more and more toward the North; and ſets, in like Manner to the Southward of the Weſt, but more and more towards the Weſt, and having paſſed that Point, ſtill onward, ſets more and more toward the North that way alſo; *i. e.* her Amplitudes both at riſing and ſetting, are every Morning and Night, more toward the North, than the preceding Morning and Night, becauſe, at this Time of the Year, the Moon aſcends from the Southern to the Northern Signs of the Zodiac, by which means, we every Night for ſeveral Nights together, enjoy more and more of her Light, till ſhe has arrived at a conſiderable Northern Latitude; in Imitation of the Sun, which about the Vernal Equinox, makes his Amplitudes, both at riſing and ſetting, more and more towards the North, till he has arrived at the Tropic of ♋.—But with this Difference, that the ſeveral Amplitudes or approaches of the Sun, towards the North, are much ſmaller, than thoſe of the Moon, becauſe the Sun takes up a Year to go thro' all the Signs of the Zodiac, while the Moon goes thro' them all in a Month. But,

The ſtrangeneſs of this Phenomenon, conſiſts in the Moon's riſing, nearly at the ſame Hour, from two or three Days before her Full, to as many after her Full; that is, from about ¾ of an Hour before 6, to about ¾ of an Hour after 6, riſing every Night a ſmall matter later than ſhe did the Night before; yet always Souths about 48 Minutes later than the preceeding Night.

Some, perhaps, may aſk the Queſtion, why the like Appearances do not happen at the Vernal Equinox, or near it? To which it may be anſwered, that at *that* Time of the Year, the Caſe is juſt the reverſe; and when a Full Moon happens on or near the Vernal Equinox, the Moon is then, always, paſſing from the Northern to the Southern Signs, and riſes upward of an Hour later every Night than the preceding Night; and her Amplitudes go more and more from the North toward the South, as in the Year, 1764, when it was a Full Moon, *March* the 18*th*, as by Reference being had to an Almanac or Ephemeris for that Year, will evidently appear: And when the New Moon happens on or near the Vernal Equinox, ſhe performs all the Phenomena, with regard to her riſing, that the Full Moon does in or near the Autumnal Equinox, as in the Year, 1765, when it was New Moon, on *March* the 21*ſt*. as by the like Reference being had to an Almanac or Ephemeris for that Year, will appear alſo: But becauſe the Moon affords no Light, at that Time, ſo no Notice is taken of it.

PROBLEM LXVIII.

The Latitude of a Place being given, to obſerve upon the Globe, at once, the Lengths of Days and Nights, with rhe Viciſſitudes of all the Seaſons throughout the Year.

Given, *London*, in Lat. 51° 32′ North.

Required, a general Repreſentation of the Lengths of Days and Nights, and changes of all the Seaſons throughout the Year.

1. Elevate the Globe to the given Latitude.

2. Bring the firſt Point of ♋ to the Meridian, and fix the Globe.

3. Obſerve all the Parallels of North Latitude from the Equator to the Tropic of ♋, which repreſent the Diurnal Arches, or Lengths of Days in the Summer half Year.

4. Obſerve all the Parallels of South Latitude, from the Equator to the Tropic of ♑, which repreſent the Diurnal Arches, or Lengths of Days in the Winter half Year.

5. If the Eye be caſt along the Ecliptic from ♈ to ♋, it ſhews where he Spring begins and ends, with its Duration.

6. Move the Eye from ♋ to ♎, and you have the Summer Quarter with its beginning and ending.

7. Continue the Motion of the Eye from ♎ to ♑, and you ſee the beginning and ending of the Autumn Quarter, with its Duration.

8. Obſerve the remaining Part of the Ecliptic from ♑ to ♈, and you ve the beginning, ending and Duration of the Winter Quarter.

Note 1. Other Parallels of Latitude or Declination may be made at Pleaſure in the Torrid Zone, beſide thoſe which are already made, either with fine pointed Chalk, or a black lead Pencil, as the Tutor ſhall find Occaſion.

2. The longer the Arches or Parallels are, the longer will the Days be, and the contrary.

3. This *Problem* is very inſtructive, inaſmuch as it ſhews (almoſt inſtantaneouſly) all the Variety of Lengths of Days and Nights, not only for every Part of the Year, but every Part of the World likewiſe; and by a Motion of the Meridian upwards and downwards, for every Latitude, both North and South alſo.

4. The Length of the Day, being at any Time or Place obtain'd, the Length of the Night is always the Complement thereof to 24 Hours.

A new and complete

DESCRIPTION

Of the TERRESTRIAL and CELESTIAL

GLOBES,

With their ſeveral Uſes.

PART IV.

Containing the Conſtruction of the *Analemma*, with its Uſe, on the TERRESTRIAL GLOBE, in 7 Problems.

THE *Analemma*, that is ſuch a Part of it (for it is but a Part of the Whole) as is uſed on the Terreſtrial Globe, is a narrow Slip of Paper, whoſe Length is equal to the Breadth of the Torrid Zone, or direct Diſtance between the two Tropics.

It contains all the Months and Days of each Month in the Year, and is divided into two Parts. The firſt Part begins at the Bottom with the Winter Solſtice, or *December* 21*ſt*, and is reckoned upwards, orderly, to the Summer Solſtice, or *June* 21*ſt*, from whence the ſecond Part begins, and is reckoned, in the like Order, downwards to the Winter Solſtice again.

The Months and Days thus laid down, and paſted on the Terreſtrial Globe, in ſome vacant Place in the Torrid Zone, correſpond exactly with the ſeveral Declinations of the Sun, from one Tropic to the other, for every Day throughout the Year.

Note 1. As Globes are not always of the ſame Diameter, ſome being larger and ſome leſs; I thought it neceſſary to give the Figure of the *Analemma*, with the Manner of conſtructing it, leaving it to every Tutor's Ingenuity to make one in Proportion to ſuch Terreſtrial Globe as he teaches by.

2. If the Tutor ſhould happen to uſe a Globe of 12 Inches Diameter, the Diſtance between the Tropics on ſuch Globe will be too ſmall to have every Day marked on the *Analemma*, and in ſuch Caſe, it may do very well to be marked for every other Day, or every third Day; and towards the Tropics every fourth or fifth Day.

3. What is done in the Figure is only for a ſmall Globe of 6 $\frac{1}{2}$ Inches Diameter.

4. The greateſt Breadth of the *Analemma*, ſhould not be above 4 Tenths of an Inch: A curious Hand will perform it in 3 Tenths or leſs.

5. The beſt Place on the Globe to place the *Analemma*, is on that Meridian, which is to the Weſtward of *California*.

The Conſtruction of the Analemma.

1. Take a large Sheet of Paper, wider than the Globe, and thereon make a Circle equal to the Diameter of it, which ſuppoſe 16 Inches.

2. Divide it into four Quadrants, by drawing two Diameters to cut each other at right Angles; each of which divide into 90 equal Parts or Degrees.

3. Let one of the Diameters repreſent the Equator; the two Ends of which Mark, with ♈ and ♎.

4. At ♈ and ♎, ſet off 23° ½, both Northward and Southward, upon the Periphery of the Circle.

5. At the Diſtance of 23° ½, draw the two Lines ♋ ♋ and ♑ ♑ to repreſent the two Tropics.

6. Where they interſect the upwright Diameter, they give the two tropical Points ♋ and ♑.

7. Parallel to the upwright Diameter draw four Lines, two on one Side and two on the other, at one Tenth of an Inch Diſtance, for the Months and Days.

8. By an *Ephemeris* you will be enabled to mark off the Months and Days, like the Example in the Plate annexed, ſetting off the firſt Day of each Month, and alſo the other Days, according to the Sun's Declination, both North and South.

9. Cut off ſo much of it as is neceſſary, and paſte it upon the Globe, and then you have the *Analemma* to work with.

Note, If Parallels of Latitude be drawn thro' every two oppoſite Degrees in the Periphery, they will ſhew the Sun's Declination; and then the following Problems may be wrought, as well upon the *Analemma*, as upon the Terreſtrial Globe.

The EXPLANATION of the *Analemma*.

The Circle divided and quartered, repreſents the General Meridian —♈ ♎ the Equinoctial—P S the Prime Vertical Circle—P the North Pole—S the South Pole—♋ ♋ ♋ the Tropic of *Cancer*—♑ ♑ ♑ the Tropic of *Capricorn*—The double Line A B the Arctic Circle—The double Line C D the Antarctic Circle—♋ ♑ the Ecliptic—The other Parallels between ♈ ♎ and P Northward; and between ♈ ♎ and S Southward are Parallels of the Sun's, or a Star's Declination—The Ecliptic is divided into the 12 Signs by a Scale of right Sines equal to 90°, or the Radius of the Circle.

PROBLEM I.

The Day of the Month being given, to find the Sun's Declination for that Day.

Given, *May 19th*.

Required, the Sun's Declination for that Day.

1. Bring the *Analemma* to the Meridian and fix the Globe; the Latitude being out of the Queſtion.

2. Obſerve what Degree is right over the given Day, for that is the Sun's Declination for that Day, *viz.* 20°.

PROBLEM II.

The Day of the Month being given, to find the Sun's Place in the Ecliptic, and his right Aſcenſion.

Given, *May 19th.*
Required, the Sun's Place, and his right Aſcenſion.

1. Bring the *Analemma* to the Meridian.
2. Hold a large Pin, or pointed Wire againſt it, directly over the given Day.
3. Turn the Globe about, till ſome ſuch Point of the Ecliptic as happens before, or on the Weſtern Side of the Summer Solſtice, meets with the ſaid Wire, and fix the Globe.

Note, It muſt be on the Weſtern Side of the Summer Solſtice, becauſe the given Day happens before the Sun arrives at the Tropic of ♋.

4. Obſerve what Part of the Ecliptic that is; for that is the Sun's Place for the given Day, *viz.* 28°½ of ♉.
5. Obſerve what Degree of the Equator is cut by the Meridian, for that is the Sun's right Aſcenſion for the given Day, *viz.* 55° from ♈.

PROBLEM III.

The Latitude of a Place, and Day of the Month being given, to find the Time of the Sun's riſing and ſetting, with its Amplitude.

Given, *London*, in Lat. 51° 32′ N. and *May 19th*;
Required, the Hour of the Sun's riſing and ſetting, with his Amplitude, at both Times.

1. Rectify the Globe for the given Latitude.
2. Bring the Middle of the *Analemma* to the Meridian, and fix the Globe.
3. Set the Index of the horary Circle to the upper XII.
4. Turn the Globe Eaſtward, till the given Day coincide with the Eaſtern Horizon, and fix the Globe again.
5. Obſerve the Index, and you will find it point to 4 *hrs.* 7 *min.* A M. which is the Time of the Sun's riſing.
6. Obſerve alſo what Degree of the Horizon is cut by the given Day, for that is the Amplitude at Sun riſing, *viz.* 34° from the Eaſt towards the North.
7. Turn the Globe Weſtward, till the given Day coincides with the Weſtern Horizon, and fix the Globe, once more.
8. Obſerve the Index again, and you will find it point to 7 *hrs.* 53 *min.* P. M. which is the Time of the Sun's ſetting.
9. Obſerve alſo what Degree of the Horizon is cut by the given Day, for that is the Amplitude at Sun ſetting, *viz.* 34° from the Weſt towards the North.

Note, By the foregoing Method, the riſing and ſetting of the Sun, with its Amplitude, may be ſeen by Inſpection, for every Day in the Year, and that almoſt inſtantaneouſly.

PROBLEM IV.

The Latitude of a Place, Day of the Month, and Hour of the Day being given, to find the Sun's Altitude and Azimuth.

Given, *London*, in Lat. 51° 32′ N. *May 19th*, at 7 A. M.
Required, the Sun's Altitude and Azimuth.

1. Rectify the Globe for the given Latitude.

2. Bring the Middle of the *Analemma* to the Meridian, and fix the Globe.

3. Set the Index of the horary Circle to Noon.

4. Turn the Globe, till the Index points to the given Hour, and fix it again.

5. Fix the Quadrant of Altitude in the Zenith.

6. Bring the Quadrant to lie over the Day of the Month given, and keep it ſteady.

7. Obſerve, on the graduated Edge, the Degrees cut by the Day given, the ſame is the Altitude of the Sun, at the given Time, *viz.* 25 Degrees.

8. Obſerve, in the Horizon, what Point of the Compaſs the Sun bears on; the ſame is the Sun's Azimuth for the given Hour, *viz.* E. nearly, or 89° from the North.

PROBLEM V.

The Latitude of a Place, and Hour of the Day being given, to find all the different Altitudes and Azimuths the Sun can have, for every Day in the Year, at that Hour.

Given, *London*, in Lat. 51° 32′ N. and 9 A. M.

Required, all the different Altitudes and Azimuths the Sun can have, for every Day in the Year, at that Hour.

1. Rectify the Globe for the given Latitude.

2. Bring the Middle of the *Analemma* to the Meridian, and fix the Globe.

3. Set the Index of the horary Circle to Noon.

4. Fix the Quadrant of Altitude in the Zenith.

5. Turn the Globe, till the Index points to the given Hour, and fix it again.

6. Bring the Quadrant of Altitude to lie over the Southern Part of the *Analemma*, and it will ſhew the Sun's Altitude and Azimuth, for the ſhorteſt Day of the Year, at the given Hour, *viz.* Altitude 5° ½, and Azimuth S. E by S. ¾ E. or 41° from the Meridian.

7. Move the Quadrant of Altitude gradually, from Day to Day, over the whole *Analemma*, and the Sun's Altitude and Azimuth will be diſcovered thereby, from the ſhorteſt to the longeſt Day, *viz.* Altitude 45° ½, and Azimuth E. S. E. and 1° E. or 68° from the Meridian.

8. Do the ſame back again for the other Side of the *Analemma*, and the ſame Altitudes and Azimuths will ſhew themſelves again, from the longeſt to the ſhorteſt Day, at the given Hour.

PROBLEM VI.

The Latitude of a Place, Day of the Month, and Sun's Azimuth being given, to find the Hour of the Day, when the Sun will be upon that Azimuth, together with the Altitude of the Sun, at the ſame Time.

Given, *London*, in Lat. 51° 32′ N. *May* 19*th*, and Sun's Azimuth 89° from the North, A. M.

Required, the Hour of the Day, when the Sun will be upon that Azimuth, together with the Altitude of the Sun, at that Time.

1. Rectify the Globe for the given Latitude.

2. Bring the Middle of the *Analemma* to the Meridian, and fix the Globe.

3. Set the Index of the horary Circle to Noon.

4. Fix the Quadrant of Altitude in the Zenith.

5. Bring the Quadrant to the given Azimuth, and keep it ſteady.

6. Turn the Globe, till the given Day in the *Analemma* coincides with the graduated Edge of the Quadrant, and hold it there.

7. Obſerve, by the Index, the Hour pointed at; for that is the Time, when the Sun comes to the given Azimuth, *viz.* 7 A. M.

8. Obſerve, what Degree of the Quadrant coincides with the Day; for that is the Sun's Altitude at the given Time, *viz.* 25 D given
egrees.

PROBLEM VII.

The Latitude of the Place, Day of the Month, and Altitude of the Sun being given, to find the Hour of the Day, and Sun's Azimuth, at that Height.

Given, *London*, in Lat. 51° 32′ N. *May* 19*th*, and Sun's Altitude 25°.
Required, the Hour of the Day, and Sun's Azimuth at the given Height.

1. Rectify the Globe for the given Latitude.

2. Bring the Middle of the *Analemma* to the Meridian, and fix the Globe.

3. Set the Index of the horary Circle at Noon.

4. Fix the Quadrant of Altitude in the Zenith.

5. Move the Globe and the Quadrant together, in ſuch Manner that the given Day and Altitude may coincide with each other.

6. Fix the Globe again, and keep the Quadrant ſteady.

7. Obſerve the Index and it will point to 7 A. M. which is the Time required.

8. Obſerve, where the Quadrant cuts the Horizon, *viz.* 89° from the North, or E. nearly, which is the Sun's Azimuth, at the given Altitude.

◆

1. Rectify the Globe for the given Latitude.

2. Bring the Middle of the Analemma to the Meridian, and fix the Globe.

3. Set the Index of the Hour Circle to Noon.

4. Fix the Quadrant of Altitude in the Zenith.

5. Bring the Quadrant to the given Azimuth, and keep it steady.

6. Turn the Globe, till the given Day in the Analemma coincides with the graduated Edge of the Quadrant, and hold it there.

7. Observe, by the Index, the Hour pointed at; for that is the Time when the Sun comes to the given Azimuth, viz. 7 A. M.

8. Observe, what Degree of the Quadrant coincides with the Day; for that is the Sun's Altitude at the given Time, viz. 25° [illegible]

PROBLEM [illegible]

The Latitude of the Place, Day of the Month, and Altitude of the Sun being given, to find the Hour of the Day, and Sun's Azimuth, at that Height.

Given, London, in Lat. 51° 32′ N. May 21, and Sun's Altitude 25°.
Required, the Hour of the Day, and Sun's Azimuth at the given Height.

1. Rectify the Globe for the given Latitude.

2. Bring the Middle of the Analemma to the Meridian, and fix the Globe.

3. Set the Index of the Hour Circle at Noon.

4. Fix the Quadrant of Altitude in the Zenith.

5. Move the Globe and the Quadrant together, in such Manner that the given Day and Altitude may coincide with each other.

6. Fix the Globe again, and keep the Quadrant steady.

7. Observe the Index, and it will point to 7 A. M. which is the Time required.

8. Observe, where the Quadrant cuts the Horizon, viz. 87° from the North to E. nearly, which is the Sun's Azimuth, at the given Altitude.

A new and complete
DESCRIPTION
Of the TERRESTRIAL and CELESTIAL
GLOBES,
With their ſeveral Uſes.

PART V.

Containing a further Uſe of the Terreſtrial GLOBE, exemplified in 45 Theorems, or certain Geographical and undeniable Truths, deduced from the foregoing Problems, with their Explications; very uſeful for the better Underſtanding the Terreſtrial GLOBE.

THEOREM I.

The Latitude of any Place is always equal to the Elevation of the Pole in the ſame Place.

Explication.

1. The Latitude of any Place is its Diſtance from the Equator, whether North or South.

2. When the Pole is in the Zenith, the Horizon and the Equator are the ſame.

3. If any Man ſhould travel directly South from the Pole towards the Equator; ſo many Degrees as he ſhall travel, juſt ſo many Degrees will his Horizon go below the Equator on one Side, as it will riſe on the other on the ſame Meridian. Hence

4. The Horizon approaches the Pole, juſt as many Degrees as the Zenith approaches the Equator. Or, which is the ſame thing, the Height of the Pole above the Horizon is equal to the Diſtance of the Place from the Equator.

THEO-

THEOREM II.

The Elevation of the Equator above the Horizon, in any Place, is always equal to the Complement of the Latitude in the ſame Place.

Explication.

As the Diſtance between the Zenith of any Place, and the rational Horizon of that Place is always equal to 90°; and the Diſtance between the ſame Zenith and the Equator is equal to the Latitude: So the Diſtance between the Equator and the Horizon (which is the Elevation of the Equator above the Horizon) muſt be the Remainder of the 90°, that is, the Complement of the Latitude. Thus, for inſtance, if the Globe be rectified for *London*, which is 51° 32′ N. then will the Equator be elevated above the Horizon 38° 28′, which is the exact Complement of the Latitude of *London*. If, on the other Hand, the Globe be rectified for either of the Poles, the Place under ſuch elevated Pole being in the greateſt Latitude, the Equator can have no Elevation at all, but is in the Horizon; and as the Complement of the Latitude, in this Caſe, is equal to nothing; ſo the Elevation of the Equator (if it may be called ſuch) is equal to nothing likewiſe.

THEOREM III.

All the Places lying under the Equator, have no Latitude, becauſe there the Computation of Latitude begins.

Explication.

The Equator is an imaginary Line or Circle, having no real Exiſtence, and is the Mid-way between the two Extremes of the Sun's Declination, North and South; and therefore for the Convenience of reckoning Latitude, no Place was found ſo proper to begin it at, as at the Equator; which was ſo called, becauſe it was found, that when the Sun came to this imaginary Line or Circle, then the Days and Nights were equal in Length all the World over, except at the Poles: And therefore it is evident by the brazen Meridian, which is numbered North and South, from the Equator (directly over which is placed a Cipher ſhewing) that Latitude begins there, and conſequently that all Places under the Equator have no Latitude.

THEOREM IV.

Thoſe two Places, lying under the two Poles, have the greateſt Latitude, becauſe there the Computation of Latitude doth End.

Explication.

As in the former Theorem, it was found expedient to produce a Line or Circle, where to begin Latitude: So it was equally as expedient to find a Place where to end it, becauſe it muſt end ſomewhere. And as all Meridians meet together in one point in the Poles; ſo no two Places could be contrived ſo well for that Purpoſe, as the Poles themſelves, they being ways, one on one Hand, and the other on the other Hand, while a Man is travelling directly under that Line. Hence thereſore it is evident by the brazen Meridian, which is numbered Northward and Southward from the Equator by 0, 10, 20, 30, &c. to the Poles, that Latitude cannot increaſe beyond either of them, but muſt end there; becauſe having paſſed the Pole, the Latitude decreaſes, or grows leſs and leſs in Proportion, as you draw nearer that Line again. And as it is known, that the whole Body of the Earth turns quite round, once in 24 Hours (the Equator being in the Middle and deſcribing the greateſt Circle:) So it was neceſſary to begin Latitude there. Likewiſe as the Earth is continually ſpinning round in this Manner, it muſt neceſſarily turn as if it was fixed upon a Spindle, which paſſes thro' the Center, and oppoſite Sides of the ſame equally diſtant from the Equator; which oppoſite Sides or Points are very fitly termed the Poles, as being the two Extremes, where the Motion is ſo exceeding ſmall as to become imperceptible, and where no two Places could be ſound ſo fit for the Latitude to terminate, as here.

THEOREM V.

All Places lying under the firſt Meridian, have nothing of Longitude, becauſe there the Computation of Longitude begins.

Explication.

Where-ever the firſt Meridian is placed (as in *England* it is placed, for Honour's Sake, at *London*) there is a Cypher put on it, ſhewing that Longitude begins at that Place, or more properly on that Part of the Equator cut by the Meridian of *London*, the Equator being in the Middle, and deſcribing the greateſt Circle. And as the Longitude of any Place is, now in *England*, reckoned either to the Eaſtward or Weſtward of the firſt Meridian: So it is very plain that at *that* firſt Meridian Longitude muſt begin; and conſequently all thoſe Places lying under that firſt Meridian, have no Longitude.

THEOREM VI.

All Places lying oppoſite to the firſt Meridian on any Part of the Globe, have the greateſt Longitude, becauſe there the Computation of, that particular Longitude doth end.

Explication.

As Longitude begins at the firſt Meridian and gradually increaſes from it both Eaſterly and Weſterly; ſo it ends at that Meridian, which is oppoſite to it, and never exceeds 180°, which is the half of 360°. Hence, if a Ship ſhould ſail due Eaſt 190° from the firſt Meridian, ſhe would (as appears by the Globe) over-run the oppoſite Meridian, and change her Longitude from Eaſt, and be in 170° Weſt Longitude. Thus by the Ship's paſſing the Meridian, oppoſite to the firſt Meridian, and thereby changing her Longitude, it is very plain that ſuch particular Longitude muſt end at that Meridian oppoſite to the Meridian given, and therefore ſuch oppoſite Meridian muſt have the greateſt Longitude.

THEOREM VII.

All Places, on either Side of the Equator, have greater or leſs Latitudes according to their Diſtances therefrom.

Explication.

As Latitude begins at any Part, or rather every Part of the Equator, and proceeds, both North and South, directly towards the Poles: So it is evident, from the Gradations on the brazen Meridian, (which increaſe from the Equator, both Northerly and Southerly, till they reach the Poles, in which Places the Latitudes end) that the nearer any Place is to the Equator, the Latitude is the ſmaller; and the nearer any Place is to either of the Poles, *i. e.* the farther it is from the Equator, its Latitude is the greater.

THEOREM VIII.

All Places lying on either Side of the Equator, or exactly under the ſame, have greater or leſs Longitude, according to their Diſtances from the firſt Meridian.

Explication.

The firſt Meridian (with the *Engliſh*) is that which paſſes thro' *London*; and where that Meridian cuts the Equator, there Longitude begins, and increaſes both Eaſterly and Weſterly, till it meets at the oppoſite Meridian. Hence, any Place, whether North or South of the Equator, or under it, the nearer it is to the firſt Meridian, the ſmaller is the Longitude, and the farther it is from it, the Longitude is the greater.

THEOREM IX.

That particular Place of the Earth, lying exactly under the Interſection of the firſt Meridian and Equator, hath neither Longitude, nor Latitude.

Explication.

As Latitude begins at the Equator, and is always reckoned on a Meridian; and as Longitude begins at ſome Meridian, called the firſt Meridian, and is always reckoned on the Equator: So that Point where ſuch firſt Meridian and the Equator interſect each other, can have neither Latitude, nor Longitude, it being the Beginning of both.

THEOREM X.

No Place can be diſtant from another, above 180°, being half the Circumference of the Globe.

Note, This is to be underſtood of the Surface of the Globe.

Explication.

Explication.

1. Latitudinally.

Suppoſe two Places, marked with Chalk, diametrically oppoſite on the Equator, as on ♈ and ♎: According to the Latitudes on the brazen Meridian, it is twice $90^\circ = 180^\circ$, which multiplied by 60, gives 10800 Nautical or Geographical Miles their greateſt Diſtance: But if either of them be removed, on the ſame Meridian, either Northerly or Southerly, tho' the Diſtance will be increaſed one Way, it will be leſſened the other Way; and therefore the neareſt Diſtance only, whether it be Northerly or Southerly, is the true Diſtance. Hence, if two Places be 200° diſtant one Way, they will be but 160° the other Way, which is the true Diſtance.

2. Longitudinally.

Suppoſe the ſame two Places diametrically oppoſite as above: According to the Longitude on the Equator, it is 180°, which multiplied by 60, gives 10800 Miles as before, for their greateſt Diſtance: But if any one of them be removed on the Equator, either Eaſterly or Weſterly, tho' the Diſtance will be increaſed one Way, it will be leſſened the other Way, and therefore the neareſt Diſtance in this Reſpect alſo, whether it be Eaſterly or Weſterly is the true Diſtance.

3. Obliquely.

Suppoſe the ſame two Places ſituated as before: If a great Circle be made to paſs thro' them any where between the cardinal Points, as the Ecliptic, the Caſe will be the ſame: And if any one of the Places be removed, on the ſame Circle, the farther they may be from each other one Way, the nearer they will be the other Way, the neareſt Diſtance being the true one. It will be the ſame, if the two Places are not ſituated as before, and a great Circle drawn to paſs thro' them; for the *Antipodes* of any Place, are at a Semi-circular Diſtance.

THEOREM XI.

All *Antipodes* being diametrically oppoſite, are diſtant from each other 6873 Nautical or Geographical Miles, at 60 to a Degree; the Circumference being always more than thrice the Diameter.

Note, This is to be underſtood by a Line drawn between the given Places thro' the Earth.

Explication.

The Circumference of the Earth on any great Circle, is 360°, which multiplied by 60, gives 21600 Miles. Now as the Diſtance of all *Antipodes* is equal to the Diameter of the Earth, and ſuch Diameter is not quite $\frac{1}{3}$ of its Circumference, but bears ſuch Proportion to it, as 7 to 22 or thereabout; it evidently follows, that any two Perſons or Places, being Diametrically oppoſite, are *Antipodes* to each other, and diſtant from each other, no more than the Earth's Diameter, which is 6873 Miles, at 60 to a Degree.

THEOREM XII.

The ſenſible Horizon, of every Place, (admitting it to be quite round) doth as often change, as we happen to change the Place itſelf.

Explication.

The ſenſible Horizon is that Circle, which is the Boundary of Sight, and where the Earth and Sky, or Water and Sky ſeem to meet. Every Perſon therefore, whereſoever ſituated, is ſomewhere within ſuch an Horizon (and if at Sea, in the Center of it, tho' upon Land it cannot properly be ſaid to be ſo) and whenever he changes his Place, whether Eaſtward, Weſtward, Northward, or Southward, or any other Point of the Compaſs, he changes his Horizon alſo, tho' it be but by a ſingle Step. The Change of the Horizon, it muſt be confeſſed, does not appear by ſuch ſmall Gradations, till a Man has travelled, ſometimes ſeveral Miles; but it is nevertheleſs true in ſmall Paſſages, how Minute ſoever, as well as in great ones: And the Diſtance between the front Arch of one Horizon, and the front Arch of another next ſucceeding, bears the ſame Proportion, or nearly ſo, as the Diſtance travelled: *i. e.* The Diſtance between the front Arches of any two ſenſible Horizons (admitting them to be quite round, as obſerved before) is the ſame as the Diſtance of their Centers; tho' the Sides on the right Hand and on the left, are continually interſecting each other.

Note 1. What is obſerved concerning the ſenſible Horizon, will in a more eſpecial Manner hold good in the rational alſo.

2. The ſenſible Horizon, upon Land, is ſo far from being round, that it is hardly ever found regular, and therefore it is almoſt impoſſible for a Man ever to be in the midſt of it; becauſe it frequently happens that the Proſpect ſhall on one Side be very ſhort, and the Horizon near at Hand, occaſioned by a very high Hill; while on the other Side the Proſpect ſhall be very diſtant, and conſequently the Horizon a great Way off. Or, he may be ſituated between two Hills, where on each Side the Boundary of Viſion is very ſhort, but at the ſame Time the Proſpect right before him very extenſive. The Truth of this is evident to every travelling Perſon. But,

3. In the open Sea, where no Land is Viſible, every Ship is in the Center of her own Horizon, let the Latitude and Longitude be what they will.

THEOREM XIII.

The apparent Semidiameter of the ſenſible Horizon, or more truly, that Diſtance, which is between any one Perſon and the utmoſt Boundary of Sight, doth frequently vary according to the Refraction of the Sun's Rays.

Explication.

As every Man ſtands in the Center of his own Horizon (admitting it to be round, as in the laſt *Theorem*): So from himſelf to the Boundary of his Sight is but the Semidiameter of that Horizon: And this Semidiameter is lenghtened by the Sun's Rays, which are bent, and by that Means make the Sun to appear higher above the Horizon than he really is; and ſometimes to be above it, when he is really below it. It is further obſervable, that a Pail filled with Water, will cauſe the Bottom, or a Piece of Silver, at the Bottom, to appear very plainly, tho' a Perſon ſtands at ſome Diſtance from it, when at the ſame Diſtance and the Pail empty, the Bottom, or the Silver at the Bottom, cannot be ſeen at all.

THEOREM XIV.

All Countries upon the Face of the whole Earth, in Reſpect to Time, do equally enjoy the Light of the Sun, and are equally deprived of the Benefit thereof.

Explication.

That is, all Countries have half a Year Day, and half a Year Night, when all their enlightened Hours are put together for Day, and all their Dark Hours are put together for Night. Thus at *London*, it may be obſerved, as the Days gradually increaſe, or lengthen till the longeſt Day, the Nights gradually decreaſe, or ſhorten, in the ſame Proportion, till the ſhorteſt Night: and on the contrary, as the Days gradually decreaſe, or ſhorten, till the ſhorteſt Day; ſo the Nights gradually increaſe, or lengthen in the ſame Proportion, till the longeſt Night, by which Means, Light and Darkneſs are upon an Equality; and from the Beginning of the Year to the End of it, the Inhabitants of that Place have half a Year of Days, and half a Year of Nights, which upon an Average, or every Day one with another, is 12 Hours Day, and 12 Hours Night.

Note 1. By 12 Hours Night is meant the Sun's being ſo long beneath the Horizon.
2. What is ſaid of *London*, may be ſaid of any other Place on the Earth, in what Latitude or Longitude ſoever ſituated.
3. Refraction, under the Poles, ought to be objected againſt the foregoing Theorem when the Sun is at, and after he has croſſed the Equinoctial; and alſo from the Sun's continuing a longer Time in the Northern, than in the Southern Signs.

THEOREM XV.

In all Places of the Earth, ſave exactly under the Poles, the Days and Nights are of an equal Length, or 12 Hours each, when the Sun comes to the Equinoctial Line.

Explication.

If the Poles, either North or South be elevated to any Latitude, except 90°, the Sun, when it is in the Equinoctial, will riſe due Eaſt, and ſet due Weſt: and then, whether the Sun be in ♈ or ♎, it will be found by the horary Circle, that from Sun-riſe to Sun-ſet is juſt 12 Hours; conſequently every Place on the Earth, of what Latitude or Longitude ſoever it be (except exactly under the Poles) have their Days and Nights equal at that Time.

THEOREM XVI.

In all Places under the Equator, the Days and Nights are always equal, notwithſtanding the Alteration of the Sun's Declination, North into South, or South into North.

Explication.

Reduce the Globe to a right Sphere; and in order to this, without taking off the Hour-circle, let three or four Pedeſtals be made in the Forms of ſo many Cubes, each of whoſe Sides ſhall meaſure two Inches and an half, and let them be placed round, upon the Horizon, at equal Diſtances, as near as may be; then take out the Globe and lay the brazen Meridian upon the Pedeſtals, with the Face or graduated Part of it upwards; then will the Meridian become a Horizon, and the horary Circle being kept on, the Index will have free Liberty to move with the Globe. In the next Place, to find the Length of the Day, with the Inhabitants at the Equator, when the Sun is on any other Point of the Ecliptic, as well as in ♈ or ♎, fix upon any Point, at Pleaſure, ſuppoſe 18° of ♉ for the Sun's Place, mark it, and bring it to the Eaſtern Side of the Horizon, which is the Place of its riſing, and put the Index to VI in the Morning (that being juſt the ſame as bringing the Sun's Place to the Meridian, and the Index at Noon) next turn the Globe, till the Sun's Place touch the Weſtern Side of the Horizon, which is the Place of its ſetting; after this, if you obſerve the Index, you will find it at VI in the Evening, the Time of the Sun's ſetting: And this holds good to all the Inhabitants of the Equator quite round the Globe of the Earth, let the Sun be in what Point of the Ecliptic it will, or which is the ſame thing, let the Sun's Declination be what it will.

THEOREM XVII.

In all Places except thoſe under the Equator, and the two Poles, the Days and Nights are never equal, except at thoſe two Times of the Year, when the Sun entereth the Signs of ♈ and ♎.

Explication.

This will appear very evidently, Firſt, by finding the Sun's Place any where in the Ecliptic on the Globe: Secondly, by elevating the Pole to any oblique Latitude: And Thirdly, by turning that Place from the Eaſtern to the Weſtern Horizon, by which it will appear, on the horary Circle, that the Day is either longer than the Night, or the Night longer than the Day, in every Place and Latitude, except at the Poles and Equator, every Day throughout the Year, except on thoſe two particular Days when the Sun enters ♈ and ♎.

THEOREM XVIII.

The nearer any Place is to the Line, the leſs is the Difference between the Length of the Days, and the Length of the Nights in the ſaid Place; and the farther any Place is removed from the Line, the Difference is the greater.

Expli-

Explication.

To the Inhabitants under the Line, the Length of Days and Nights are always equal, as has been before obſerved in *Theorem* XVI, becauſe the Sun ſets at right Angles with the Horizon, whatever his Declination is: But to the Inhabitants of *London*, which is diſtant from the Equator 51° 32′ the Days and Nights differ in their Length, according to the Declination of the Sun, and according as he riſes and ſets more Oblique, at one Time than at another. Hence, in Proportion to the obliquity of the Line, the Sun makes at his riſing and ſetting with the Horizon, ſuch is the Difference between the Length of Days and Nights at any Place; and therefore in the Latitude of *London*, becauſe the Sun riſes and ſets abundantly more oblique, when he is in the Tropic of ♋, than when he is in the Equator, it follows, that the Difference between the Days and Nights on the Parallel of *London*, is greater than at the Equator. Suppoſe then four Places 20° diſtant from each other, the firſt of which being on the Equator, and the laſt next the North Pole; in the firſt Place, every Day throughout the Year, is juſt 12 Hours long, and every Night the ſame, as appeared before, at *Theorem* XVI, by reducing the Globe to a right Sphere: In the next Place, elevate the Pole to the Latitude of 20°; then fix upon ſome Point in the Ecliptic for the Sun's Place; ſuppoſe 18° of ♉, mark it, and bring it to the Meridian, and put the Index at Noon: then if the Sun be firſt brought to the Eaſtern Horizon, the Index will point at 5 *hrs.* 30 *min.* in the Morning; and afterwards to the Weſtern Horizon, the Index will point at 6 *hrs.* 30 *min.* in the Afternoon, whereby the Length of the Day appears to be 13 Hours.

Elevate the Pole to the Latitude of 40°, bring the Sun's Place (the ſame as before) to the Eaſtern and then to the Weſtern Horizon, obſerving the Index, both Ways, and the Length of the Day will be, for the Latitude of 40°, 14 Hours long.

Elevate the Pole again to the Latitude of 60°, bringing the Sun to the Eaſtern and Weſtern Horizon, as before; and the Day, in that Latitude, will be 16 *hrs.* long. Thus you have the Length of the Day

	hrs.	*min.*		*hrs.*	*min.*		*hrs.*	*min.*
1. At the Equator - -	12	0	Night	12	0	Diff.	0	0
2. At 20° Latitude - -	13	0		11	0		2	0
3. At 40° Latitude - -	14	0		10	0		4	0
4. At 60° Latitude - -	16	0		8	0		8	0

Hence it appears, that the nearer any Place is to the *Line*, the Difference between the Length of the Day, and the Length of the Night is leſs, and the farther any Place is from the *Line*, that Difference is greater. And this Difference is greater or leſs, not only with Reſpect to the Difference of Latitude, but alſo, with Reſpect to the Difference of the Sun's Place in the Ecliptic. For if the Sun's Place be in 30° of ♊, or, which is the ſame thing, in the firſt Scruple of ♋, the Difference between the Length of the Day and the Length of the Night, in the ſeveral Latitudes beforementioned, will ſtill be greater; and that Difference will alſo be more or leſs, according as the Sun is more or leſs, diſtant from the Equator. Thus, for Example, If the Sun be in the firſt Scruple of ♋, the Length of the Day will be

1. At

	hrs.	*min.*		*hrs.*	*min.*		*hrs.*	*min.*
1. At the Equator - -	12	0	Night	12	0	Diff.	0	0
2. At 20° Latitude - -	13	15	ditto	10	45	ditto	2	30
3. At 40° Latitude - -	15	0	ditto	9	0	ditto	6	0
4. At 60° Latitude - -	18	30	ditto	5	30	ditto	13	0

And thus, may Tables be made to ſhew the Length of the Day, and the Length of the Night, in every Degree of Latitude, for the ſame Degree of the Sun's Place in the Ecliptic: And likewiſe for every Degree of the Sun's Place in the Ecliptic in the ſame Latitude.

THEOREM XIX.

In all Places, lying under the ſame Parallel of Latitude, the Days and Nights are of the ſame Extent, all the Times of the Year.

Explication.

That is, whatever the Length of the Day and Night is at *London*, on the 28*th* Day of *May*, the ſame Day and Night are of the ſame Length, at every other Place having the ſame Latitude. Thus when the Sun enters the Tropic of ♋, *June* 21, making the Day at *London*, 16 *hrs*. 35 *min*. and the Night 7 *hrs*. 25 *min*. the ſame Day and Night are of the ſame Length, at every other Place in the Latitude of 51° 32′, which is the Latitude of *London*, with this ſmall Difference only, that the more any Place is to the Eaſtward of *London*, the Day begins ſo much the ſooner, at ſuch Place, than it does at *London*; and the more any Place is to the Weſtward of it, the Day begins ſo much the later.

THEOREM XX.

Three or four Places being given on the Globe, that lie between the Equator and either of the Poles, and equidiſtant from one another, the Extent of the longeſt Day in thoſe Places, doth not increaſe proportionably to the Diſtances of the Places themſelves.

Explication.

When the Sun is in the Tropic of ♋, and the Latitude pretty high, the Sun is then very Oblique to the Horizon, at his riſing and ſetting, whereas at the Equator, he riſes and ſets at right Angles, with the Horizon; and conſequently. when the Sun is in its greateſt obliquity, in ſuch a Latitude, it takes more Time to reach 20° Altitude, when he is riſing, or takes more Time at 20° Altitude to ſet, than when he has the ſame Altitude at the Equator. Suppoſe, for Example, four Places at 20° Diſtance from each other, the firſt at the Equator, the ſecond at 20°, the third at 40°, and the fourth at 60°, as in *Theorem* XVIII, all in North Latitude, then the Length of the longeſt Day will be,

1. At

	h.	*m.*
1. At the Equator - -	12	0
2. At 20° Latitude - -	13	15
3. At 40° Latitude - -	15	0
4. At 60° Latitude - -	18	30

Hence it appears, that the Extent of the longeſt Day in the Places, or Latitudes aforementioned, does not increaſe in Proportion to the Diſtance of the Places themſelves ; and this is plain from the common Difference of the given Latitudes, which is juſt 20°; but the Differences between the Lengths of the ſeveral longeſt Days, in the ſaid Latitudes, are not the ſame, becauſe thoſe ſeveral Differences, not only increaſe, as the Latitudes increaſe, or draw nearer to the Pole, but that increaſe is ſtill increaſing, and every Difference from the Equator, grows larger and larger. Thus the Learner, from producing equal Diſtances of Latitude from the Equator, may learn to frame a Table of the unequal Differences of the Lengths of the longeſt Days belonging to ſuch Latitudes, and thereby be informed that equal Differences of Latitudes do not produce equal Differences of the Lengths of the longeſt Days in thoſe Latitudes.

THEOREM XXI.

Three or more Places being given on the Globe, that lie on different Parallels between the Equator and one of the Poles, in which the Length of the longeſt Day doth equally increaſe, the Diſtance between the Parallels of thoſe Places is not equal one to the other.

Explication.

By the foregoing *Theorem* it was made to appear, that ſeveral Parallels of Latitude, on either Side of the Equator, being equally diſtant from each other, the Increaſe of the longeſt Day will be more than in Proportion to the Diſtances of thoſe ſeveral Parallels ; and therefore, by parity of Reaſon it muſt follow, that any Number of Latitudes, whoſe longeſt Day is equidiſtant from each other in Time, yet thoſe Parallels of Latitude ſhall not be equidiſtant.

Example.

Take four ſuch Parallels of Latitude, whoſe longeſt Days differ from each other juſt one Hour ; that is, let the firſt longeſt Day be 13 Hours, the ſecond 14, the third 15, and the fourth 16 Hours long, the ſeveral Latitudes belonging to theſe longeſt Days may be found by the Table of Climates foregoing, p. 12, or by *Problem* 34 : Thus the longeſt Day conſiſting of

	°	′		°	′
13 *Hours* is in the Latitude of	16	43			
14 ditto - - - - - - -	30	47	Diff.	14	4
15 ditto - - - - - - -	41	22	ditto	10	35
16 ditto - - - - - - -	49	1	ditto	7	49

Hence it appears, that the Diſtance between the Parallels of the above Places is in great Diſproportion, to the Difference of Time between their longeſt Days: And it further appears, by the above Table, that the nearer the Approach is to the Pole, the ſeveral Differences grow ſmaller and ſmaller. Thus the Learner might be taught to make a Table of the Difſerences of Latitudes, beginning at the Equator, whoſe longeſt Day is 12 Hours, and gradually increaſe half an Hour, till the longeſt Day makes 24 Hours, which is in the Latitude of 66°½, *i. e.* at the Polar Circles, and be thereby informed that equal Differences of the Lengths of the longeſt Day, will not produce equal Differences of Latitude.

THEOREM XXII.

Three or more Places being given, whoſe Diſtances from the Equator, to either Pole, exceed one another in Arithmetical Proportion; the Length of the longeſt Day in one, doth not keep the ſame Analogy to the other, according to the Proportion of their Diſtances.

Explication.

The Truth of this *Theorem* is, in Part, manifeſt from an Obſervation made in *Theorem* XVIII, where four Places, or rather Parallels of Latitude were made choice of, *viz.* the firſt at the Equator, the ſecond at 20°, the third at 40°, and the fourth at 60°, the common Difference being 20°, all which, with their longeſt Days, and Differences, ſtand thus,

	°		h.	m.		h.	m.		°
1.	0	Longeſt Day	12	0	Diff.	0	0	Diff. of Par^{ls}	0
2.	20	ditto – –	13	15	ditto	1	15	ditto – –	20
3.	40	ditto – –	14	50	ditto	1	35	ditto – –	20
4.	60	ditto – –	18	40	ditto	3	50	ditto – –	20

Hence it appears, that the Parallels of Latitude made choice of, are in Arithmetical Progreſſion or Proportion, exceeding each other by 20°, but the Differences between the longeſt Day belonging to thoſe Latitudes do not, in the ſame Order, exceed each other; for the nearer the Approach is made towards either of the Poles, that Difference enlarges, and therefore the ſeveral longeſt Days in the propoſed Latitudes do not keep the ſame Analogy, with the Proportion of the Diſtances of thoſe Latitudes.

THEOREM XXIII.

In all Places of the *Torrid Zone*, the Morning and Evening Twilight is leaſt; in all Places of the *frigid Zones* it is greateſt, and in all Places of the *temperate Zones* it is a Medium between the other two.

Explication.

The Twilight, as has been obſerved, at *Problem* XXXV, is a feint Light, between Sun-ſhine and Darkneſs, which begins before Sun-riſing, when he is 18° below the Eaſtern Horizon, and ends at his riſing; and begins again at Sun-ſet, and holds till he is 18° below the Weſtern Horizon. Now it is to be obſerved, that to the Inhabitants, at the Equator, the Sun always riſes at VI, and ſets at VI; and always, both at riſing and ſetting makes right Angles with the Horizon; and as 15° on the Equator make one Hour of Time; ſo 18° are equal to 1 *hr.* $\frac{1}{5}$ = 1 *hr.* 12 *min.* the Time of Twilight: Hence if the Latitude is increaſed Northerly, and the Sun's Declination ſhould, at the ſame Time be Southerly, the Twilight will not be leſs than 1 *hr.* 12 *min.* but if the Declination ſhould be Northerly, with the Latitude, the Twilight will then increaſe in ſome Proportion (tho' not in a direct Proportion) as the Sun riſes or ſets obliquely to the Horizon; but at $23^\circ\frac{1}{2}$, which is the Limit or Boundary of the Sun's Declination, ſuppoſing the Latitude of the Place be the ſame on the longeſt Day there, the Twilight will be but 1 *hr.* 30 *min.* Again,

In the *Frigid Zones*, the greateſt Twilight of all, which is at the Poles, is from *Sept. 22d*, when the Sun enters ♎ to *Nov. 13th*, making in all one continued Twilight for 53 Days together, including Refraction; or, from *January 28th* to *March 21ſt*, when the Sun enters ♈, making the ſame continued Twilight, for the ſame Number of Days, including Refraction, as appears by *Prob.* LXIV.

Note 1. At the two Poles of the World, the *Refraction* is the greateſt: And tho' the Sun, at the North Pole, enters ♎ on the 22*d* Day of *Sept.* at his ſetting, and at the South Pole, on the 21*ſt* of *Mar.* enters ♈, at his riſing: yet by virtue of the *Refraction*, he ſeems to appear, at both Times, and Places above the Horizon, when he is really below it.

2. From *Refraction*, it comes to paſs that the Sun, juſt at the real Times of his riſing and ſetting, in any Latitude, is never ſeen, but a mere Phantom or likeneſs of the Sun only.

From the North Pole to the Arctic Circle, and from the South Pole to the Antarctic Circle, the Twilight varies according to the Sun's Declination and the Change of Latitude, tho' not a great deal; the greateſt Twilight, at the Arctic Circle, beginning when the Sun is about 14° in ♈, *i. e. April 4th*, and holds till the Sun has paſſed as many Degrees beyond the Tropic of ♋, as it was before it, there being no Night all that Time, including *Refraction*, as before. The like may be ſaid at the Antarctic Circle, when the Sun is about 14° in ♎ moving towards the Tropic of ♑. From each Polar Circle to the Tropic next it (by which the two *temperate Zones* are diſtinguiſhed) the Twilight is of a middle Duration, between the two Extremes of longeſt and ſhorteſt: And here likewiſe it varies, according to the Sun's Declination, as well as according to the Change of Latitude. At the Arctic Circle (which is the ending of the North *frigid Zone*, and beginning of the North *temperate Zone)* the longeſt Twilight begins about *Ap. 4th*, and ends about *Sept. 8th*, when the Sun, in that Latitude, on both Days, riſes at 5 *hrs.* 15 *min.* and ſets at 6 *hrs.* 45 *min.* whereby there is at leaſt each Night 10 *hrs.* 30 *min.* Twilight; the Sun not being above 18° below the Horizon all that Time.

Note, As the Sun advances in the Ecliptic, from *April 4th* aforeſaid, the Twilight will grow ſhorter and ſhorter, till it arrives at the Tropic of ♋: when there will be no Twilight at all, becauſe the Sun will not be depreſſed below the Horizon at that Time: But when the Sun's Place is farther in the Ecliptic, from the Tropic of ♋, the Twilight will begin to lengthen again; and if it be ſtill nearer to the Line, the Twilight will be divided into Morning and Evening Twilight; becauſe the Sun at Midnight will be depreſſed below the Horizon, above 18°, and ſtill more ſo in the ſame Latitude, when his Declination appears to be South.

If you come to the Latitude of *London*, *viz.* 51° 32′ N. the longeſt Twilight is produced on the 23*d* Day of *May*, and on the 19*th* Day of *July*, on which Days, the Sun riſes at 4 *hrs.* 2 *min.* and ſets at 7 *hrs.* 58 *min.* conſequently (the Sun not being more than 18° below the Horizon, during his Depreſſion) there will be but 8 *hrs.* 4 *min.* continual Twilight, in every 24 Hours, before and after which two Days, that is, before the ſaid *May* 23*d*, and after the ſaid *July* 19*th*, the Twilight will be divided into Morning and Evening Twilight: From all which it appears, that the Twilight is continually diminiſhing, from the Poles to the Equator, both in Reſpect to the Change of Latitude, and Sun's Place in the Ecliptic; conſequently, the Twilight is longeſt at the Poles, or in the *frigid Zones*; ſhorteſt at the Equator, or in the *torrid Zone*; and at a Medium in the two *temperate Zones*.

THEOREM XXIV.

To all Places lying within the *torrid Zone*, the Sun is duly Vertical twice a Year; to thoſe under each Tropic once, but to them in the *temperate* and *frigid Zones* never.

Explication.

As the Sun is limitted, within the *torrid Zone*, and is continually paſſing from one Tropic to the other, it muſt of neceſſity paſs twice in the Year over any one Place, lying between thoſe Tropics. Thus, for Example, ſuppoſe, any Tower in *St. Vincent*, one of the *Cape de Verd* Iſlands, in Lat. 17° N.: In the Sun's paſſage from the Tropic of ♋ to the Tropic of ♑, it muſt neceſſarily be Vertical to that Place; and when the Sun returns from the Tropic of ♑ to the Tropic of ♋, it muſt of neceſſity paſs over the ſame Place, or be Vertical to it again, both which Times will happen conſiderably within the Year: The ſame may be ſaid of any other Place between the Tropics: And if the Place be upon the Equator, the Sun will be Vertical to ſuch Place, twice within half a Year, very nearly, in as much as it is but a very little above half a Year from the Equator to either of the Tropics and back again. But, if the given Place ſhould be under either of the Tropics, the Sun will be Vertical but once within the Year; for tho' it is ordinarily ſaid, that from the Sun's Departure from any Point in the Heavens to its return to the ſame Point again is a Year, yet in fact the Year is paſt, tho' it ſhould be but a ſingle Minute; and from Mid-day in the firſt Scruple of ♋ to Mid-day in the firſt Scruple of ♋ again is above the Year; and therefore the Sun can be Vertical but once in the Year to any Part under either of the Tropics. If the given Place be out of the *torrid Zone*, as *London*, or any other Place within the *temperate* or *frigid Zones*, the Sun can never be Vertical to ſuch Place, becauſe it never comes beyond the Tropics, as was ſaid before.

THEOREM XXV.

In all Places of the *frigid Zones*, the Sun appeareth every Year without ſetting, for a certain Number of Days, and diſappeareth for the ſame Space of Time: And the nearer unto, or the farther from the Pole thoſe Places are, the longer or ſhorter is his continued Preſence in, or Abſence from the ſame.

Expli-

Explication.

Let any Part of either of the *frigid Zones* be brought to the Pole of the Horizon, *i. e.* the Zenith, and the Tropic, next that Pole, will, all of it, appear above the Horizon; conſequently, when the Sun is in that Tropic, next the elevated Pole, the Sun will not ſet for ſeveral Days; and to the ſame Place, when the Sun is in the oppoſite Tropic, he will totally diſappear for as many Days; and if the given Place be remote from the Pole, the Number of Days, in which the Sun will conſtantly ſhine, will be fewer, and the nearer ſuch Place is to the Pole, the Number of Days will be the greater.

Note, Tho' the Expreſſion is, That the Sun will ſhine for ſeveral Days together, in any Part of the *frigid Zones*, it muſt be underſtood no otherwiſe, in that Latitude, than, as the Sun is continually going round once in 24 Hours; ſo the ſame Number of Circles that he makes is equal to the ſame Number of Days in a far leſs Latitude, where Day and Night ſucceed each other continually: The real Truth being that how long ſoever the Sun continues above the Horizon, for the ſame Time it makes but one Day in ſuch an high Latitude.

THEOREM XXVI.

In all Places exactly under the Arctic and Antarctic Circles, the Sun appears every Year, at his greateſt Decline, from one whole Day without ſetting, and entirely diſappears another, Refraction excepted; but daily riſes and ſets in thoſe Places, at all other Times as elſewhere.

Explication.

Let a Place be given any where, exactly under the Arctic Circle, which mark with Chalk, and let that Place be brought to the Pole of the Horizon, *i. e.* let the North Pole be elevated to the Latitude of the Place: Next ſuppoſe the Sun in his greateſt North Declination, *viz.* in the firſt Scruple of ♋, or juſt arrived at the Tropic of ♋, then will the Sun be above the Horizon, for one whole Day, the oppoſite Side of the Tropic being juſt even with the rational Horizon. Keep the Globe in the ſame Situation, and ſuppoſe the Sun, at the ſame Time, in his greateſt South Declination, *viz.* in the Tropic of ♑, or firſt Scruple of that Sign, it is evident by the Globe, that the Sun, when in that Point, will, to the Inhabitants of the Arctic Circle, intirely diſappear for one Day, and no more, Refraction excepted as before, and all the other intervening Days he will riſe and ſet, at the given Place, as elſewhere.

THEOREM XXVII.

In all Places between the Equator and the North Pole, the longeſt Day and ſhorteſt Night is always, when the Sun hath the greateſt Northern Declination; and the ſhorteſt Day and longeſt Night is, when he hath the greateſt Southern Declination.

Explication.

The Sun's greateſt North Declination (as has been before obſerved) is when he is in the firſt Scruple of ♋; and when there, to all the Inhabitants on the North Side of the Equator, the Days are longer than the Nights, with this Difference only, that the longeſt Day, in every Place, is not of the ſame Length, nor the ſhorteſt Night, becauſe of the Differences of Latitudes; but yet in all, the Day is longer than the Night.— Thus, for Example, the longeſt Day at *London*, or any other Place in that Latitude, is 16 Hours and a half, and the Night but 7 Hours and a half; but if the given Place be in any leſs Latitude, the longeſt Day in that Latitude will not be ſo long as that at *London*, and the Night will be longer: Alſo, if the given Place be in a ſuperior Latitude than at *London*, the longeſt Day will be longer than that at *London*, and the Night ſhorter, and ſo in Proportion, as any given Place is nearer to, or farther from the North Pole. Hence, by parity of Reaſon, to any of the Inhabitants in North Latitude, when the Sun is in the Tropic of ♑, *i. e.* in his greateſt South Declination, the Day will be ſhorter than the Night; and the nearer any one approaches to the North Pole, the ſhorteſt Day will ſhorten, and the longeſt Night will lengthen; but in all, the Day will be ſhorter than the Night.

THEOREM XXVIII.

In all Places between the Equator and the South Pole, the longeſt Day and ſhorteſt Night is always, when the Sun hath the greateſt Southern Declination; and the ſhorteſt Day and longeſt Night, when he hath the greateſt Northern Declination.

Explication.

What has been ſaid in the preceding *Theorem*, might ſerve here alſo; but for fear it ſhould prove a little defective, by referring to that; I ſhall obſerve that, with a little Variation, almoſt the ſame Words, that were uſed there, will ſerve here likewiſe. Thus,

The Sun's greateſt South Declination (as has been before obſerved) is when he is in the firſt Scruple of ♑; and when there, to all the Inhabitants on the South Side of the Equator, the Days are longer than the Nights, with this Difference only, that the longeſt Day in every Place is not of the ſame Length, nor the ſhorteſt Night, becauſe of the Differences of Latitudes; but yet in all, the Day is longer than the Night. Thus, for Example, the longeſt Day at the Eaſtern End of the Straits of *Magellan*, which is about 51° ½, or any other Place in that Latitude, is 16 Hours and a half, and the ſhorteſt Night, but 7 Hours and a half; but if the given Place be in any leſs Latitude, the longeſt Day in that Latitude will not be ſo long, as that at the Straits of *Magellan*; and the Night will be longer: Alſo, if the given Place be in a ſuperior Latitude, than at the Straits of *Magellan*, the longeſt Day will be longer than that at the ſaid Straits, and the Night ſhorter; and ſo in Proportion, as any given Place is nearer to, or farther from the South Pole. Hence, by parity of Reaſon, to any of the Inhabitants in South Latitude, when the Sun is in the Tropic of ♋, *i. e.* in his greateſt North Declination, the Day will be ſhorter than the Night; and the nearer any one approaches to the South Pole, the ſhorteſt Day will ſhorten, and the longeſt Night will lengthen; but in all, the Day will be ſhorter than the Night.

THEO-

THEOREM XXIX.

In all Places under the Equator, the Meridian Shadow of a Stile, erected perpendicular, doth caſt itſelf North, for one half of the Year, and South, during the other half.

Explication.

The Equator, by Inſpection on the Globe, is placed in the Middle of the *torrid Zone*, *i. e.* exactly between the two Tropics; conſequently, when the Sun is in his Meridian on the North-ſide of the Equator, and a Stile erected perpendicular on the Equator, the Shadow of that Stile muſt be due South for ſo long a Time, as the Sun's Declination is North, which (the Sun's continuance in the Northern Six Signs ſomewhat longer excepted) is juſt half a Year; and the other half Year, when the Declination is South, the Shadow of the ſame Stile every Day, when the Sun comes to the Meridian, will be due North.

THEOREM XXX.

In all Places, under the Equator, there is no Meridian ſhadow on thoſe two Days of the Year, when the Sun enters the Signs of ♈ and ♎.

Explication.

When the Sun is coming from the Tropic of ♑, and advances towards the Tropic of ♋, on the *21ſt* Day of *March* he enters the firſt Degree of ♈, and then the Sun is ſaid to be in the Equinoctial; and then alſo, in any Place, or every Place under the Line, when the Sun comes to the Meridian of that Place, it is Vertical, and conſequently, a perpendicular Stile, or a ſtreight Pole of the greateſt Length that can be erected, provided it be quite upright, will give no Shadow at all, at the Hour of XII. When the Sun has paſſed the Equinoctial, and is coming back from the Tropic of ♋ to the Equinoctial again, on the *21ſt*, or *22d* of *Sept.* he enters the firſt Degree of ♎, and then the ſaid Stile or Pole (ſuppoſing it to be ſtanding) at the Hour of XII, will caſt no Shadow, the Sun at that Time being Vertical, as before.

Note, What is ſaid concerning the Meridional Sun in any Part of the Equator, will hold good in any other Part of the *torrid Zone*, between the two Tropics, whether it be North or South of the Equator, when the Sun happens to be Vertical in that Place.

THEOREM XXXI.

The nearer any Place is to, or the farther it is from the Equator, the ſhorter or longer, accordingly, is, the Meridian Shadow of a perpendicular Stile in ſuch a Place; and the nearer to, or farther from the Vertex of any Place, the Meridian Sun is, the ſhorter or longer will the Meridian Shadow be.

Explication.

This is chiefly to be underſtood of Places out of the *Torrid Zone*, either Northward or Southward, where the Noon Shadow is always caſt one Way, *i. e.* in North Latitude, always Northward, and in South Latitude, always Southward: Not, but it will hold good within the *Torrid Zone* likewiſe, but not in ſo eminent a Degree; beſide, ſome regard muſt be had to the Sun's Declination, becauſe the Noon Shadow of any upright Stile, will lengthen and ſhorten in the ſame Place, juſt as the Sun is nearer to or remoter from that Place, and this both within the *Torrid Zone*, and out of it; for it is certain, that at *London*, ſuch a Stile will give a longer Shadow, when the Sun is in the Tropic of ♑, than when he is in the Tropic of ♋. Again,

Suppoſe the Sun to be in the Tropic of ♋; in any Place under that Circle, at Noon, he makes no Shadow, but the farther one goes towards the Equator, at that Time, the Shadow will be the longer; and if any Place be aſſigned, that is, three or four Degrees farther North, the Noon Shadow at that Place will be very ſhort, and yet the Place more remote from the Equator: Wherefore it muſt be underſtood, when the Sun is in the Equinoctial, and then it will hold good in every Part of the Globe, either North of the Line, or South of it, that the nearer any Place is to the Equator, the ſhorter will be the Shadow, and the farther one is from it, it will be the longer.

THEOREM XXXII.

The farther Places are removed from the Equator, not ſurpaſſing 66° of Latitude, the greater is the Sun's Amplitude, or that Arch, contained between the due Eaſt or Weſt Points of the Horizon, and the Center of the Sun at his riſing or ſetting. And the greateſt, thoſe on which the Sun riſeth and ſetteth on the Days of the Summer and Winter Solſtices.

Explication.

That the Sun's Amplitude is greateſt at the Solſtices, is evident from raiſing the Pole, whether North or South (ſuppoſe *London* in Latitude 51° 32′ N.) and then bringing the two ſolſticial Points, *viz.* ♋ and ♑ to the Horizon; in this Caſe 'tis very plain, that the Amplitude in both Reſpects, can be no larger in that Latitude, becauſe the Sun cannot go beyond thoſe two Points. If you travel Southward, the Amplitude will be leſs, becauſe the Pole being elevated to the Latitude of that Place, the ſolſticial Points will be nearer to the Eaſt and Weſt Points. If you travel Northward of *London*, and thereby increaſe your Latitude to (ſuppoſe) 66°, the Summer Solſticial Point, or firſt Scruple of ♋, will, by the Rotation of the Globe, be depreſſed juſt below the Horizon, and conſequently the Sun riſes in that Latitude very little Eaſtward of the North Point, and ſets very little Weſtward of it: The Winter Solſticial Point, or firſt Scruple of ♑, in the ſame Latitude, will be juſt above the Horizon; conſequently the Sun will riſe very little Eaſtward of the South Point, and ſet very little Weſtward of it. In the firſt, the Day will be upwards of 23 Hours long, and the laſt not an Hour. If you travel farther North, (ſuppoſe) 70°, the Sun has no Amplitude at all, becauſe he does not ſet in the Summer, in that Latitude, for ſeveral Days, and in the Winter, he never riſes for as many. The ſame will hold good, when the Sun is in any other Point of the Ecliptic, whether the Declination be North or South.

THEOREM XXXIII.

In all Places lying under the ſame Semicircle of the Meridian, the Hours, both of Day and Night, are always the ſame in one as in the other.

Explication.

This is evident from any of the Meridional Lines: For if you make choice of any Meridian, let the Index of the horary Circle ſtand at what Hour you pleaſe to ſet it, that Hour is the ſame to all Places, lying under that Meridian; *i. e.* When it is Noon in one Place, it is Noon in all; and when it is Midnight in one Place, it is Midnight in all, and ſo of all the intermediate Hours.

THEOREM XXXIV.

In all Places, both of the Northern and Southern Hemiſpheres, that lie under oppoſite Parallels of Latitude, the Seaſons of the Year are not the ſame in one as in the other.

Explication.

This *Theorem* holds good in the moſt eminent Degree in the *temperate Zones*; not but that it carries ſome Weight with it, even in the *Torrid Zone*, where it is always Summer, and in the *frigid Zones*, where it is always Winter.

1. *In the temperate Zones.*

Let *London*, in Lat. 51° 32′ N. be given for one Place, and its *Antiæci*, or Place of like Latitude, on the ſame Meridian South, be given for another: It is evident from common Experience, that when it is Summer in the North Latitude, it is Winter in the South Latitude, and the contrary; and this is owing to the Sun's Declination, either North or South; theſe two Seaſons changing according as he moves from one Tropic to the other: And for this Reaſon alſo, it is, that the longeſt Day with one Place is the ſhorteſt with the other: Yet it muſt be underſtood, that when the Sun gets half Way in his receding from either Tropic, or is in the Equinoctial, the Seaſon at that Time is the ſame, or nearly ſo, in both Places; *i. e.* it is neither Winter nor Summer, but between, or the Beginning of both, and the Length of the Day the ſame with both. If, in the two given Latitudes, inſtead of *Antiæci*, a Place in one Parallel be made *Antipodes* to the other, there will ariſe another Difference, to wit, of the Times added to thoſe beforementioned; becauſe, when it is Noon Day in one, it will be Mid-Night in the other; and ſo of any other Hour, whatever it is of the Day in one Place, it will be the ſame Hour of the Night in the other.

2. *In the torrid Zone.*

Let one Place be given in 20° N. Latitude, at Pleaſure; its *Antiœci* will then be on the ſame Meridian in 20° S. Latitude. However, tho' the Hour of the Day and Night will be the ſame in both Places, yet the Length of the Day will not be the ſame to both, at the ſame Time; and the longeſt Day with one, will be the ſhorteſt Day with the other, as in the *temperate Zones:* And tho' neither Froſt, nor Snow are found in this *Zone*; yet there is a ſenſible Difference between the Sun's being firſt in one Declination and then in another; and there will alſo be a diverſity of wet and dry Seaſons, and of windy and calmer Weather. If any two Places in the Parallels juſt mentioned, be made *Antipodes* to each other, there will be the ſame Difference of Day and Night, and particular Hour, as in the *temperate Zones.*

3. *In the frigid Zones.*

Here it is always Froſt and Snow; yet the Degrees of Cold are not ſo intenſe, when the Sun is above the Horizon, as when he is below it; conſequently, tho' it is Winter in both *Zones* at the ſame Time, yet in all probability, that *frigid Zone*, which is enlightened by the Sun, is not ſo ſeverely Cold as the other *frigid Zone*, which is buried in Night: Notwithſtanding, it is affirmed by ſome, that the two Poles, in their turns, are the hotteſt Places on the Globe, becauſe they have each of them, half a Year continual Day: But *Capt. Phipps*, who went to explore the North Pole, has made it appear to the Contrary; ſince he was not able to get there, thro' the large Quantity of Ice. If, therefore, two Places within the *frigid Zones*, marked at Pleaſure, be made *Antiœci* to each other, they will, tho' at that Diſtance, have the ſame Meridian, but the Day of one, will be longer than the Day of the other, if it ſhould happen to be Day at both Places, at the ſame Time, except, when the Sun is in the Equinoctial, as aforeſaid. If any two given Places in the *frigid Zones* be made *Antipodes* to each other, the Difference of Day and Night, Hour of the Day, and Hour of the Night will be the ſame, as mentioned in the *temperate Zones.*

THEOREM XXXV.

In all Places, ſituate in a parallel Sphere, the Circle of the Sun's diurnal Motion, runs always Parallel, or very nearly ſo, to the reſpective Horizons of ſuch Places.

Explication.

This can be underſtood only of the two Poles, all other Places between them and the Equator, making an oblique Sphere; and that the Sun runs nearly Parallel to the Horizon, in his diurnal Motion is plain from Senſe; and if the Globe be truſted to, in this Caſe, it will appear, by one or more Rotations of it, that the Sun is exactly Parallel to the Horizon. Thus, rectify the Globe for the North Pole; next fix upon any Point in the Ecliptic, that is above the Horizon, for the Sun's Place, and mark it;

then turn the Globe about, as many Times as you pleaſe, and that Point will never get higher or lower, but always run exactly Parallel to the Horizon: But this, however it may appear, is not ſtrictly true; for the Sun, as he moves from one Degree in the Ecliptic to another, in his Paſſage from one Tropic to the other, always makes a ſpiral Line; and in his return from either Tropic, croſſes every one of thoſe Spirals, till he arrives at the other Tropic again, and then goes on, in the ſame Spirals, croſſing and recroſſing each other as before. This may be made appear very clearly, by turning a Thread progreſſively round a Stick, at equal Diſtances, and then bringing that Thread back again in the ſame progreſſive Manner, which will repreſent the Sun's Motion, as evidently, as any one thing elſe.

THEOREM XXXVI.

In all Places, ſituated in a right Sphere, the Circle of the Sun's diurnal Motion is perpendicular, or nearly ſo, to the reſpective Horizons of ſuch Places.

Explication.

No Place can make a right Sphere, but ſuch as is upon or under the Line: conſequently, every Place under the Line, makes a right Sphere; as has been explained very largely in former *Theorems* and *Problems*. In the next Place, that the Sun makes a ſpiral Line, as he paſſes from one Tropic to the other, has been made to appear very plainly, in the laſt *Theorem*; and therefore, tho' it be commonly aſſerted, that (in a right Sphere) the Circle of the Sun's Motion is perpendicular to every Horizon in that Sphere, yet ſuch Aſſertion is not ſtrictly true; for as the Sun makes Spirals continually to and from each Tropic, as obſerved before, thoſe Spirals muſt admit of ſome Obliquity, tho' it may be ſmall, and therefore cannot be at right Angles with the Horizon. However, as thoſe Spirals come very near to ſo many Perpendiculars, every Circle of the Sun's Motion is commonly aſſerted to be, as abovementioned, perpendicular to every Horizon of a right Sphere.

THEOREM XXXVII.

In all Places, ſituated in an oblique Sphere, the Circle of the Sun's diurnal Motion is always oblique unto, or cutteth the Horizon of ſuch Places, at unequal Angles.

Explication.

Let four Places be given at Pleaſure, in the Latitudes of 30°, 40°, 50°, and 60° North, and mark them on the Globe with Chalk. Next, fix upon ſome Point of the Ecliptic, for the Sun's Place, which ſuppoſe 26° of ♊, and mark it with Chalk alſo: If the North Pole be elevated to the ſeveral given Latitudes; and at each Elevation, if the Sun's Place be brought to the Eaſtern and Weſtern Horizons, it will be very Viſible, that the Sun not only both riſes and ſets obliquely to the Horizons of thoſe ſeveral Latitudes, but that the farther thoſe are North, the greater is the Obliquity, and conſequently, the Circle of the Sun's diurnal Motion, muſt cut the Horizon at unequal Angles in thoſe Latitudes.

THEOREM XXXVIII.

If the Difference of Longitude in two Places be juſt 15°, the People reſiding in the Eaſt, will reckon the Time of Day ſooner by one Hour than thoſe in the Weſt. If the Difference of Longitude be 30°, they will reckon two Hours ſooner; if 45°, three Hours; and if 60°, then four Hours.

Explication.

This will be found very eaſy, if it be conſidered, that the Equator is divided into 360°: Next, that this Number being divided by 24 Hours, which are the Hours in one natural Day, the Quotient will give 15° for one Hour. Now, let two Places be agreed on at Pleaſure, and marked, whoſe Difference of Longitude is juſt 15° (without any regard to the Latitude) bring the firſt to the brazen Meridian, and put the Index to XII, (or any other Hour, if it be liked better) then bring the next Place, whoſe Longitude is 15° Eaſterly, to the Meridian; look upon the Index, and you will ſee, that the ſecond Place is then one Hour before the firſt Place: If you fix upon another Place, whoſe Longitude is 30° Eaſterly of the firſt, and bring it to the Meridian, you will find by the Index, that the Place, whoſe Longitude is 30° Eaſtward of the firſt, is two Hours ſooner: Fix upon another, whoſe Longitude is 45° Eaſtward of the firſt, and bring it to the Meridian, and then you will find by the Index, that ſuch Place is earlier in Time by three Hours: And, if you mark a Place in 60° Longitude, and bring it to the Meridian, ſuch Place will then be four Hours ſooner in Time than the firſt; that is, the Sun will riſe ſooner, come to the Meridian ſooner, and ſet ſooner to the Eaſtern Inhabitants.

Note, By reckoning the like Degrees Weſtward, for every 15°, the People will have their Time of the Day, one Hour later than thoſe in the Eaſt; and ſo in Proportion for any Number of Degrees, greater or leſs than 15°.

THEOREM XXXIX.

If a Ship ſets out from any Part, and ſteering Eaſtward, doth entirely ſurround the Globe of the Earth, the People of the ſaid Ship in reckoning their Time, will gain one Day compleatly at their Return; or count one Day more than thoſe reſiding at the ſaid Port: If Weſtward, they will loſe one Day, or reckon one Day leſs.

Explication.

If it be conſidered, that when a Ship ſails Eaſtward, ſhe comes ſooner to her Noon-day, and conſequently, the Sun ſets ſooner, than if the ſaid Ship was at a Stand, it will be very evident, that the People in that Ship muſt, at the long run, be a Day forwarder in their Reckoning, than thoſe People from whence they ſet out; nor can it be otherwiſe, becauſe to the People in ſuch ſailing Ship, the Day is always ſhorter than it is to the Inhabitants at Reſt; and by thus bringing the Sun to his Meridian every Day in leſs than 24 Hours, and conſequently, ſhortening every Day, it muſt of neceſſity, make an Alteration in the Time of the Day, compared with thoſe Inhabitants, from whence the Ship ſet out at firſt; and, by conſequence, gain one whole Day at leaſt, in the Circumference of the Globe.

If the ſaid Ship ſhould ſail Weſterly, the Caſe would be juſt the reverſe, becauſe every Day would be lengthened, and every Meridional Sun would be more than 24 Hours diſtant. Thus, by making the Day longer to ſuch Ship in Motion, than to the Perſons at Reſt, ſome Time muſt be loſt every Day to the Inhabitants in ſuch moving Ship; and at laſt, in one Circumference of the Globe, there muſt be a Day loſt; that is, the People in the Ship, when they arrive at the Place from whence they firſt departed, would be a Day at leaſt, behind in their Reckoning.

THEOREM XL.

If two Ships ſet out from the ſame Port, at the ſame Time, and both ſurround the Globe of the Earth, one ſteering Eaſt, and the other Weſt, they will differ in reckoning their Time two compleat Days at their Return, ſuppoſing they arrive on the ſame Day.

Explication.

From what was ſaid in the Explication of the preceding *Theorem*, it cannot be hard to conceive how two Ships, ſailing both from one Port, the one Eaſt and the other Weſt, when they meet again, that they ſhould differ, in their reckoning of Time two compleat Days. For if the Ship that ſails Eaſt, gets a Day forward of true Time, by her ſhortening the Days every Day ſhe ſails; and if the Ship, that ſails Weſt loſes a Day, or is a Day backward of true Time, by her lengthening the Days every Day ſhe ſails, then thoſe two Ships muſt of neceſſity, differ in their Account of Time, two compleat Days; *i. e.* ſuppoſing the true Time of meeting to be *June* the 20*th*, the Ship that ſailed Eaſt, will, at the End of her Reckoning have *June* 21*ſt*, and the Ship that ſailed Weſt, will have *June* the 19*th*, at the End of her Reckoning.

THEOREM XLI.

If ſeveral Ships ſet out from the ſame Port, either at the ſame or different Times, and do all ſurround the Globe of the Earth, ſome ſteering due South, and others due North, and arrive again at the ſame Port, the reſpective People of thoſe ſeveral Ships, at their Return, will not differ from one another in reckoning their Time, nor from thoſe who reſide at the ſaid Port.

Explication.

The ſame Meridian keeps the ſame Hours of the Day: And were any Number of Ships to ſail, ſome due North and others due South, the reſpective Hours of the Day will be the ſame to them all; and were they to ſurround the Globe a thouſand Times, the reſpective Days and the Hours of the Day would be the ſame to them all, when they meet again; For having never altered their Longitude, they cannot differ in Time,

but

but the Hours are the ſame to them all in their reſpective Latitudes, whether it be Mid-day, Mid-night, or any other intermediate Hour; except in the Caſe of oppoſite Meridians, and then when it is Mid-day in one, 'tis Mid-night in the other, but this makes no Difference at the Time of meeting again.

THEOREM XLII.

If two Ships ſet out from different Places, ſuppoſe *London* and *Gibraltar*, and both ſail, by an Angle of Poſition with the Meridian, that is, upon a great Circle, due Eaſt, thoſe Ships will not ſail in parallel Lines, but thoſe Lines will interſect each other, and meet in an Angle.

Explication.

Bring *London* to the Zenith, and fix the Quadrant of Altitude over it due Eaſt; then by the Side of it draw a fine Chalk-line. Next, bring *Gibraltar* to the Zenith, and fix the Quadrant of Altitude due Eaſt over that alſo: then draw a fine Line with Chalk, by the Side of it; ſo ſhall an Angle be made by theſe two Lines cutting each other.

THEOREM XLIII.

The Zenith of every Place is in the Pole of its own rational Horizon; being every Way juſt 90° from it.

Explication.

Elevate the Pole to the Latitude of the Place given (ſuppoſe *London*) and bring that Place to the Meridian, then fix the Globe. Next, place the Quadrant of Altitude in the Zenith; *i. e.* over the given Place: — Then, if the Quadrant of Altitude be turned quite round, it will appear, that the Zenith of the Place given, is juſt 90° from the rational Horizon.

This is further evident, from common Obſervation, by any Quadrant, where the Line paſſing thro' the firſt Degree, when properly held, points directly upwards, and the Line paſſing thro' the 90th Degree is parallel to the Horizon: Conſequently, as every Pole is 90° from its own Horizon; ſo the Zenith of any Place muſt be in the Pole of the Horizon of the ſame Place. In ſhort, the Zenith or Vertex of any Place, is the very Pole of the Horizon of that Place; for the Pole of every great Circle is 90° diſtant therefrom: The Horizon is a great Circle, the Zenith is always 90° diſtant from the Horizon, therefore, the Pole of the Horizon and the Zenith are co-incident, and Synonimous.

THEOREM XLIV.

The North and South Points have their Terminations, but the Eaſt and Weſt have none.

Explication.

If a Traveller paſſes on a Meridian, due North, till he arrives at the North Pole, he will be at the greateſt Latitude; but, if he continues travelling from thence on the ſame, or any other Meridian, he will then decreaſe his Latitude and go full South. And if he ſtill goes on, and croſſes the Line, he will then change his Latitude, North into South, and increaſe it Southwards, till he arrives at the South Pole, where will be his greateſt South Latitude; and if he paſſes from thence, his Latitude will again decreaſe, and by ſurrounding the Globe he will change North Latitude into South, and South into North, by which it will evidently appear, that the North and South Points have their Terminations, which muſt be at the Poles of the World But, if a Traveller ſets out any where, and goes due Eaſt, tho' he ſhould go round the Globe a Thouſand Times, he will ſtill be going on Eaſt, without ever being able to change it into the Weſt, while he continues on the ſame: the like, if a Traveller goes due Weſt.

THEOREM XLV.

Every Place, to its own Inhabitants, ſeems uppermoſt on the Globe of the Earth.

Explication,

It is a known Maxim, in Philoſophy, that every Thing naturally inclines to its own Center: Now the Earth being round, and Mankind being ſome on one Side of the Globe, and ſome on the other (and as it were ſome on the Top of it, and ſome at the Bottom of it, having Feet to Feet) makes nothing againſt this: for by the univerſal Law of Nature, whatever is Earthly, will incline to the Earth. All Bodies attract each other, in Proportion to the Quantity of Matter they contain. By this Law of Attraction or Gravity, impreſſed by the Great Creator of the Univerſe, the Planets are retained in their Orbits, and the Solar Syſtem conſerved. It is by Attraction and Coheſion, that the Parts and Particles of every Body unite with each other, and all tend to the Center, that is the Center of Gravity: Hence, upward and downward, are only relative Terms with us, as they Reſpect the Heavens, or the Center of Gravity in the Earth: And therefore, whatever is farther removed from that Center, than we ourſelves are, is ſaid to be upwards; and whatever is nearer the ſaid Center, is expreſſed to be downwards. Hence, our *Antipodes*, are on the Top of the Globe, as well as we, and have as much Right to think ſo, and be ſo: For they have the ſame Heavens for their Canopy, and the ſame Center of Gravity under their Feet, that we have; and this is the very ſame Thing with us: And therefore, it is found by Experience, that let a Man travel where he will, he always imagines himſelf, at the uppermoſt Part of the Globe of the Earth: Moreover, whether a Man travels or not, by the Earth's Rotation on its own Axis, as well as in its Orbit, he, and all the World change their Situation, with Reſpect to the Heavens; and are, according to the common Expreſſion, ſometimes Heads upwards, ſometimes Heads downwards, and ſometimes ſideways; tho' each Man appears to himſelf to be always uppermoſt.

Explication.

If a Traveller [illegible] Meridian, due North, till he arrives at the North Pole, he will meet the greatest Latitude; and if he continues his going from thence on the same, or the next Meridian, he will then decrease his Latitude and go full South. And if he still goes on, [illegible] Line, he will then change his [illegible] into South, and [illegible] Southwards, till he arrives at the South Pole, [illegible] his greatest South Latitude; and [illegible], and by [illegible] of the Globe [illegible], and South [illegible] North and South Points [illegible] Terminations, which must be at the Poles of the World. But, if a Traveller [illegible] any where and goes due East, tho' he should go round the Globe [illegible] Times, he will still be going on East, without ever being able to change it into the West, till he continues on [illegible]

PROPOSITION [illegible]

Every Place, is to some Inhabitants [illegible] uppermost on the Surface of the Earth.

Explication.

It is a common Maxim in Philosophy, that every Thing naturally inclines to its own Center: Now the Earth being round, and Mankind living [illegible] on every Side of the Globe, and none on the [illegible] on the Top of it, and some at the Bottom of it, having Feet to Feet, makes [illegible] against this: for by the universal Law of Nature, whatever is Heavy, will incline to the Earth: All Bodies [illegible] each other, in proportion to the Quantity of Matter they contain. By this Law of Attraction and Gravity, [illegible] by the Great Creator of the Universe, the Planets are retained in their Orbits, and [illegible] system [illegible] the Particles of [illegible] with each other, and all tend to the Center, that is the Center of Gravity: Hence, upward and downward, are only relative Terms [illegible] they Respect the Heavens, [illegible] Gravity [illegible] And therefore, whatever is farther remov'd from that Center [illegible] [illegible] is inclined to the [illegible] Hence, [illegible] [illegible] as we [illegible] have the same [illegible] [illegible] Gravity under their Feet, that we have; and that [illegible] [illegible] And therefore it is found by [illegible] where he will, he always imagines himself [illegible] the uppermost Part of the Globe of the Earth: Moreover, whether [illegible] Round [illegible] World [illegible] change their Situation, each subject to [illegible] to the common Supposition, [illegible] [illegible] downwards, and [illegible] [illegible] [illegible]

A new and complete
DESCRIPTION
Of the TERRESTRIAL and CELESTIAL
GLOBES,
With their ſeveral Uſes.

PART VI.

Containing a further Uſe of the Terreſtrial GLOBE, exemplified in 56 *Paradoxes*, or certain infallible Truths, expreſſed in Terms ſeemingly contradictory and inconſiſtent; with their Solutions, diſtinguiſhed into *Geographical*, *Philoſophical* and *Aſtronomical*; very neceſſary towards a thorough underſtanding the Diſpoſition of the natural, as well as the Uſe of the artificial GLOBE.

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1. *GEOGRAPHICAL PARADOXES.*

PARADOX I.

THERE are two remarkable Places on the Globe of the Earth, in which there is only one Day and one Night, throughout the whole Year.

Solution:

Theſe two Places, are the two Poles of the World, *viz.* the North Pole, and the South Pole; in both which Places, the Sun is continually going round about; at the North Pole from the Left-hand to the Right; and at the South Pole from the Right hand to the Left, it being in both Places (but alternately) ſix Months, nearly, above the Horizon, making one entire Day, and the next ſix Months below the Horizon, making one entire Night.

PARADOX II.

There are ſome Places on the Earth, in which it is neither Day nor Night, at a certain Time of the Year, for the Space of 24 Hours.

Solution.

At 66°, North or South Latitude, when the Sun is in the oppoſite Tropic, he will then be ſo far depreſſed below the Horizon, as to admit of Twilight only for 24 Hours, or thereabout, during which Time it cannot be called Day, becauſe the Sun will be then but juſt below the Horizon; and it cannot be called Night, becauſe, tho' the Sun is then below the Horizon, yet not low enough to occaſion Darkneſs in that Latitude.—Therefore, elevate the North Pole to 66°, and the Sun being then in the Tropic of ♑, will be juſt below the Horizon, where he cannot ſtay long, but muſt be above the Horizon preſently.

Note, The Caſe is the ſame, when the South Pole is elevated to 66°, South Latitude, and the Sun in the Tropic of ♋.

PARADOX III.

There are two certain Places on the Globe, where it is neither Day nor Night, twice a Year, for 53 Days together.

Solution.

At the two Poles of the World, when once the Sun is depreſſed below the Horizon, it ceaſes to be Day: And as the Sun makes a ſpiral Line; ſo every 24 Hours he becomes more and more depreſſed below the Horizon, from the 21*ſt* Day of *Sept.* when he enters ♎, till the 14*th* Day of *Nov.* and again, from the 24*th* Day of *Jan.* to the 21*ſt* Day of *Mar.* at the North Pole; and from the 21*ſt* Day of *Mar.* when he enters ♈ to the 13*th* Day of *May*, and again, from the 31*ſt* Day of *July* to the 21*ſt* of *Sept.* at the South Pole, in all which Time, he then is not above 18° below the Horizon; and therefore, from the Time that the Sun firſt appears, at either Pole, to the Time that he gets 18° below the Horizon to his Appearance again, at either Pole, it is neither Day nor Night, but Twilight.

PARADOX IV.

There is a certain Place on the Globe, of a conſiderable Southern Latitude, that hath both the greateſt and leaſt Degree of Longitude.

Solution.

Wherever Longitude begins, there it ends: ſo that if *London* be reckoned quite round the Globe, the ending of the 360°, and the beginning of the firſt Degree are exactly at the ſame Point. And this holds good, whether the Place be in North or South Latitude, becauſe the Differences of Latitudes make no Difference, with regard to the firſt and laſt Degree of Longitude, which are always reckoned on the Equator.

Note, This holds good, according to the old Way of reckoning *Longitude* in *England*; but not now, as the *Longitude* ends at 180° both Ways.

PARADOX V.

There are three remarkable Places on the Globe of the Earth, that differ both in Longitude and Latitude, and yet all lie under the ſame *Meridian.*

Solution.

Any three Places under the ſame Meridian muſt differ in Latitude; and that they alſo differ in Longitude muſt ariſe from each Place, making its firſt Meridian different from each of the reſt.

Or,

It may be underſtood of the artificial Globe and brazen Meridian only, where one of the three Places may be in 50° North Latitude and 20° Eaſt Longitude; the ſecond under the North Pole, *viz.* 90° North, and Longitude 0°; and the third may be in 20° North Latitude, and 160° Weſt Longitude. Thus will the three Places lie under the brazen Meridian, and all of them differ in Latitude and Longitude.

PARADOX VI.

There are three remarkable Places on the Continent of Europe, that lie under three different *Meridians,* and yet all agree both in Longitude and Latitude.

Solution.

For three Places to lie under different Meridians, and be all of the ſame Latitude, may very well agree, becauſe they muſt all lie under the ſame Parallel of Latitude; but to agree, all of them, in Longitude likewiſe, can be no otherwiſe, than by each Place fixing the firſt Meridian, any equal Number of Degrees to the Eaſt or Weſt of each other. Thus, if one of them fixes the firſt Meridian at *London,* the ſecond 10° Eaſtward of *London,* and the third 20° Eaſtward of *London;* and their Meridional Diſtance from each other be 10°, and each of them 20° diſtant from its own firſt Meridian, they will all be 20° Eaſt Longitude, according to their own Reckonings, tho' they differ one from another. Or, according to ſome, it may be but a meer Quibble; for altho' the Latitude and Longitude of each Place may be different, yet all may agree, that thoſe Latitudes and Longitudes are right.

PARADOX VII.

There is a particular Place on the Earth, where the Winds, though veering round the Compaſs, do always blow from the North Point.

Solution.

This can be no where elſe, but at the South Pole. For, if a Man be ſuppoſed to ſtand directly under that Pole, whether the Wind blows in his Face, or on his Back, or on either Side of him, 'tis all one ; for as it can come from no other Point than the North, it muſt be a North Wind.

Note, The like may be ſaid at the North Pole, where the Wind always blows from the South Point.

PARADOX VIII.

There are divers Places in the Continent of *Africa,* and in the Iſlands of *Sumatra* and *Borneo,* where a certain kind of Sun-dial being duly fixed, the Gnomon thereof will caſt no Shadow at all, during ſeveral Seaſons of the Year; and yet the exact Time of the Day be known thereby.

Solution.

Not only in the Iſlands of *Sumatra* and *Borneo,* or any other particular Place in *Africa,* but in every Place within the *torrid Zone,* where the Sun is Vertical, it will, at that Time, caſt no Shadow. Hence, if an Horizontal-Equinoctial-Dial be fixed, according to the Latitude of the Place, when the Sun is Vertical, the Gnomon will caſt no Shadow at all: And as this is always when the Sun is in the Meridian, it can be at no other Time than at XII at Noon.

PARADOX IX.

There is a certain Iſland in the *Atlantic* Ocean, which being deſcried by a Ship, twelve Leagues diſtant, by Eſtimation, and bearing due Eaſt of the ſaid Ship, the true Courſe for hitting the ſaid Iſland, is to ſteer ſix Leagues due Eaſt, and as many due Weſt.

Solution.

This is to be underſtood in Part concerning Longitude, and not of the Points of the Compaſs altogether; and can be reſolved no otherwiſe, than when the firſt Meridian happens to be exactly in the Mid-way, between the ſaid Ship and Iſland. Then, ſuppoſing the ſaid Ship to be ſix Leagues Weſtward of the firſt Meridian, ſhe muſt ſteer thoſe ſix Leagues due Weſt, *i. e.* Weſt Longitude, and then, by changing the Longitude, Weſt into Eaſt, ſhe muſt ſteer the next ſix Leagues due Eaſt, both in Longitude, and alſo, according to the Point of the Compaſs to make the ſaid Iſland.

PARADOX X.

There is a noted Place in the great *Atlantic* Ocean, where a briſk *Levant* is abſolutely the beſt Wind, for a Ship, that is to ſhape a due Eaſt Courſe, and yet ſhe ſhall ſtill go before it.

Solution.

1. It muſt be underſtood, that a *Levant* is an Eaſt Wind.

2. If the Place to which the ſaid Ship is to ſail, be due Eaſt of the Port to be ſailed from, then may it be ſaid, that the Ship is to ſhape her Courſe due Eaſt. But, as the Ship cannot ſail in that manner (it being over Land) but may do it the contrary Way, tho' it be a great Way farther about, ſhe may then ſhape her Courſe due Weſt, and ſail before the Wind, till ſhe gains her intended Port.

Suppoſe, for Example, a Ship to be on the Line, in 95° Weſt Longitude, and is to ſail to *Prince* Iſland, which is a little Iſland, about one Degree Northward of the Line, in 9° Eaſt Longitude; at the ſame Time, let it be imagined, that there is a briſk Eaſt Wind, blowing quite round the Globe: By the Globe, it will appear, that the Ship ſhould ſhape her Courſe due Eaſt; but, as ſhe cannot ſail directly againſt the Wind, ſhe muſt ſail Weſt, and by that means go before the Wind. Thus, will the Ship accompliſh her Voyage, by ſailing due Weſt, tho' the Place ſhe is ſailing to lies due Eaſt of the Place ſhe ſailed from. Or,

It may be underſtood of any particular Harbour, that requires an Eaſt Wind to bring any Ship out of it; though when ſhe gets out of it, ſhe muſt ſhape her Courſe due Eaſt to gain her intended Port.

PARADOX XI.

There is a remarkable River on the Continent of *Europe*, over which is a Bridge, of ſuch a Breadth, that above 3000 Men, abreaſt, may paſs along upon the ſame, and that without crowding one another in the leaſt.

Solution.

This may be underſtood two Ways.

1. It is well known, that ſeveral Rivers run under-ground for a long Way: And, if the ſeveral Tracts of Ground covering ſuch Rivers be allowed, in this Caſe, for Bridges, 3000 Men, and more, abreaſt, may paſs over them very eaſily.

2. If any ordinary Bridge be underſtood; it will hold good this Way too, if the Men paſſing over it go Sideways, becauſe they will then be abreaſt, tho' they go not ſtraight forward, as in the firſt Caſe.

PARADOX XII.

There are ten Places of the Earth, diſtant from one another 300 Miles and upwards, and yet none of them hath either Latitude or Longitude.

Solution.

This may be underſtood two Ways.

1. If thoſe Places be underſtood on the Surface of the Earth, they muſt be all of them upon the Equator, and then they can have no Latitude: And if every one fixes the firſt Meridian at his own Place, they can have no Longitude likewiſe.

2. If they be underſtood within the Earth, and not upon it (becauſe Latitude and Longitude, in fact, belong only to the Surface of it) you may conceive an imaginary Line, either by way of Diameter, or Arch of a Circle, drawn any where thro' the Body of the Earth, and to run thro' the ſaid ten Places; thoſe Places then will have neither Latitude nor Longitude.

PARADOX XIII.

There are two diſtinct Places of the Earth, lying under the ſame Meridian, whoſe Difference of Latitude is 60°, and yet the true Diſtance between thoſe Places doth not really ſurpaſs 60 Geographical Miles.

Solution.

The two ſuppoſed Places, as above, being of the Earth, and not upon the Earth, implies that they muſt be within the Earth: Conceive, then, an Angle, whoſe angular Point is at the Center of the Earth; one Side ſtretching itſelf to the Surface of it any where at the Equator, the other to 60° of Latitude; the Diſtance between theſe two Points, will then be $60° \times 60 = 3600$ Miles: But if the Idea be carried along the ſame Lines towards the Center, and an Arch of a Circle be ſuppoſed to be made at ſuch a Diſtance from the Center, as ſhall bring ſuch two Places within 60 Miles of each other, the Latitude of ſuch two Places, will be the ſame with thoſe upon the Surface of the Globe of the Earth aforeſaid.

PARADOX XIV.

There are two diſtinct Places of the Earth, lying under the Equator, whoſe Difference of Longitude is completely $86°\frac{1}{2}$; and yet the true Diſtance between theſe two Places is not full 86 Geographical Miles.

Solution.

This is ſomething relative to the Solution of the laſt *Paradox*: For, if an Angle be imagined to be made at the Center of the Earth, and one Side of it extending itſelf from the Center to the Equator, where Longitude begins, and the other to $86°\frac{1}{2}$ of Longitude on the Equator alſo, theſe two Points on the Surface of the Earth, will be $86 \times 60 + 30 = 5190$ Miles diſtant: But if the Idea be carried along the ſaid two Lines towards the Center, and an Arch of a Circle be imagined to be drawn from one Side to the other, ſo as to bring ſuch two Places within 86 Geographical Miles, or leſs; ſuch two Places will be of the ſame Longitude, within the Globe of the Earth, as thoſe two upon it, and have the ſame Difference of Longitude.

PARADOX XV.

There are three diſtinct Places of the Earth, all differing both in Longitude and Latitude, and diſtant from each other 2000 Miles complete, and yet they do all bear upon one and the ſame Point of the Compaſs.

Solution.

This may be underſtood two Ways.

1. With Reſpect to the Poles: All Places are South of the North Pole, and all Places are North of the South Pole, be the Latitude, Longitude, or Diſtance of each what it will.

2. With Regard to the Spiral, Loxodrome, or Rumb Line, made by a Ship, or Perſon travelling on any one Point of the Compaſs, between the Cardinals, which ſuppoſe S. E. from *Madrid* 2000 Miles, the ſecond Place will be S. E. of the firſt, and differ both in Longitude and Latitude from *Madrid*; and if he travel 2000 Miles more on the ſame Rumb, the third Place will be S. E. of the ſecond, yet differ both in Longitude and Latitude from them both.

PARADOX XVI.

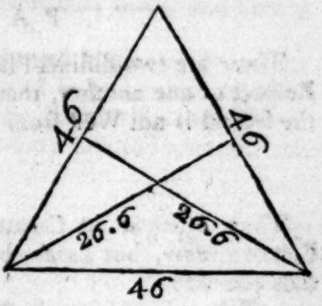
There are three diſtinct Places on the Continent of *Europe*, equidiſtant from one another (they making a true Equilateral Triangle, each of whoſe Sides doth conſiſt of 1000 Miles) and yet there is a fourth Place ſo ſituated in Reſpect of the other three, that a Man may travel on Foot from it to any of them, in the Space of one artificial Day, at a certain Time of the Year; and that without the leaſt Hurry or Fatigue whatſoever.

Solution.

The three Places abovementioned muſt be on the Continent, near the North Pole: two of them in the higheſt Latitude that can be on ſuch Continent, and the third in a leſs Degree; the fourth being fixed in the Center of the aforenamed Places, makes the Diſtance between that and either of the other three, abundantly ſhorter than between the given Places themſelves, and reduces it to the Proportion of about 4 to 7; that is, the Diſtance from the middle Place to either of the other, is about 578 Miles, a little more or leſs, according to the following plain Computation.

1. Make an equilateral Triangle at Pleaſure, but at preſent, ſuppoſe each Side 46 Miles.
2. Place a Point in the Center, which will be 26.6 Miles diſtant from the other three Places.
3. Say by the Rule of Three,

As the Side 46
Is to the Side 1000
So is the Diſtance 26.6



To the Diſtance of the fourth Place, from the other three in the *Paradox, viz.* 578.2 + Miles.

$$4' \overset{2)}{\frac{578}{1000}} \Big(\overset{7)}{\frac{289}{500}} \Big(\overset{5)}{\frac{41}{71}} \Big(\overset{2)}{\frac{8}{14}} \Big(\frac{4}{7}$$ rejecting Remainders.

Then, if the certain Time of the Year, as abovementioned, be when the Sun is in ♊ and ♋, the artificial Day will conſiſt of ſeveral Months, *viz.* 3 Months; and thus may a Man travel from the Middlemoſt to either of the other, without the leaſt Hurry or Fatigue, ſuppoſing at the ſame Time, that the Way be good, and in a ſtraight Line, without any Impediment.

PARADOX XVII.

There are three diſtinct Places on the Continent of *Europe*, lying under the ſame Meridian, and at ſuch a Diſtance, that the Latitude of the third, ſurpaſſeth that of the ſecond, by ſo many Degrees and Minutes exactly, as the ſecond ſurpaſſeth the firſt; and yet, the true Diſtance of the firſt and third from the ſecond, or intermediate Place, is not the ſame by a great many Miles.

Solution.

In the firſt Place, it muſt be underſtood, that the Globe of the Earth is not quite round, as it is generally underſtood, but an oblate Spheroid, or flattened a little at the Poles, ſomething reſembling a Bowling-Green Bowl, or a flattiſh Turnep.

In the next Place, admit three Places as above, one in 10° Latitude, another in 40°, and another in 70°; it will be pretty evident, in ſuch Caſe, that if a Line paſs from the firſt Place to the ſecond, thro' the Earth, and another paſs thro' the Earth alſo, from the ſecond Place to the third, the ſecond Line will be ſhorter than the firſt, by many Miles, becauſe of the ſharper Curve of the Surface of the Earth; and this is what is meant by the true Diſtance, which is not meaſured upon the Surface of the Earth, but by Lines drawn thro' it.

> *Note*, This will hold good alſo upon the Surface of the Earth; for the Meridians being *Spheroidal*, the Lengths of the Degrees are unequal, and the more ſo towards the Poles.

PARADOX XVIII.

There are two diſtinct Places on the Continent of *Europe*, ſo ſituated, in Reſpect of one another, that though the firſt lies Eaſt from the ſecond, yet the ſecond is not Weſt from the firſt.

Solution.

Thus *Biſnagar* in *Cormandal*, Weſt of the *Ganges* in *India*, bears due Eaſt of *London*, but *London* bears N. W. by N. ½ W. of *Biſnagar*, which is thus proved:

1. Bring *London* to the Meridian, and rectify the Globe for that Latitude, and fix it.
2. Fix the Quadrant of Altitude over *London*, and lay it over *Biſnagar*.
3. Obſerve what Point of the Compaſs in the Horizon is cut by the graduated Edge, and you will find it to be due Eaſt, which ſhews that *Biſnagar* is due Eaſt of *London*.

4. Rectify the Globe, for the Latitude of *Biſnagar*, and fix the Quadrant of Altitude over it.

5. Lay it on *London*, and obſerve the Point of the Compaſs on the Horizon, which you will find to be N. W. by N. ½ W. or N. W. ½ N.

Note 1. Upon the Line, all Places lie due E. and W. of each other, but the farther from it, the given Places are, the more they deviate from this Rule.

2. The Bearings abovementioned, are neither of them by the Compaſs, but by an Angle of Poſition.

PARADOX XIX.

There is a certain *European* Iſland, the Northermoſt Part of which doth frequently alter its Latitude and Longitude.

Solution.

There are ſeveral (ſaid to be) floating Iſlands, in a large Lake near St. *Omer's*, in *French Flanders*, moſt of them inhabited, and moveable by Ropes tied to ſtrong Poſts, fixt in the Ground, in one of which is a Church with a Monaſtery, dedicated to St. *Bernard*, where not only the Northermoſt Part thereof, but even the whole of it alters both its Latitude and Longitude, by being ſhifted from one Part of the Lake to another, at the Pleaſure of the Inhabitants, on thoſe Iſlands; or on the Borders of the Lake. See *Gordon's Geographical Grammar, Page* 109.

PARADOX XX.

It may be clearly demonſtrated by the Terreſtrial *Globe*, that it is not above 24 Hours ſailing from the River *Thames* in *England*, to the City of *Meſſina* in *Sicily*, at a certain Time of the Year; provided there be a briſk North Wind, a light Frigate, and an Azimuth Compaſs.

Solution.

This is to be underſtood of the artificial Terreſtrial *Globe*, and horary Circle; Thus,

The Difference of Longitude, between *London* and *Meſſina* is 16°, which being reduced into Time, by the Hour-circle and Index, make no more than 1 *hr.* 4 *min.* As to the certain Time of the Year, briſk North Wind, light Frigate and Azimuth Compaſs, they are only inſerted to render the *Paradox* more intricate and obſcure.

PARADOX XXI.

There is a certain Iſland, ſituated between *England* and *France*, and yet that Iſland is farther from *France*, then *England* is.

Solution.

Guernſey, lies between *England* and *France*, and is about 26 Miles from *France*, neareſt, and *England* is but 21 Miles from *France*, between *Dover* and *Calais*.

Note, The Iſle of *Wight* is ſtill farther from *France*, and yet is between *England* and *France*.

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PARADOX XXII.

There is a certain Spot of Ground ſo ſituated, that if 20 Men ſet out from thence on 20 different Meridians, they muſt all of them unavoidably travel due North.

Solution.

This is the *South* Pole, where let a Man turn himſelf which way he will, he muſt face the North.

PARADOX XXIII.

There is a certain Tract of Land, exactly two Miles in Length, and its Breadth a Quarter of a Mile. Now the Situation of it is ſuch, that if a Man begins to go thro' it, the firſt Mile he ſhall travel full North, and the next Mile he ſhall travel full South, and yet he ſhall go ſtraight forward, without turning either to the Right-hand, or to the Left.

Solution.

At the North Pole, on the ſame Meridian, one Mile towards the Pole is full *North*, and the other Mile from the Pole, in a direct Line, is full *South*.

PARADOX XXIV.

There are 13 Places on the Continent, in *Europe*, whoſe neareſt Diſtance being juſt one Mile, makes them all equidiſtant, as you paſs regular from one to another; and yet it is impoſſible to bring any more than two of them in a right Line.

Solution.

They are in a Circle.

PARADOX XXV.

There are 10 Places, all under the ſame Meridian, which are placed exactly 10 Miles one from another, and yet their Situation is ſuch, that it is impoſſible for them all to be equidiſtant.

Solution.

Any two Places, not next to one another, muſt be more diſtant than thoſe that are; and the firſt and laſt are the moſt diſtant of all.

PARADOX XXVI.

There is a certain Place upon the Globe of the Earth, where, if 72 Men were placed cloſe together in a ſmall Circle, with their Faces outward (the Center of which Circle muſt of neceſſity be behind every one of them) and if every Man was to travel ſtraight forward, they would all go full North: And if they were to continue travelling on that Point of the Compaſs, they would, after having gone about 5400 Miles, be placed in a certain Circle ſideways, at 300 Miles diſtant from one another, the Center of which Circle would be directly under the Feet of every Man; and if they went forward about 5400 Miles more, they would all meet together again in another Circle, with their Faces inward, the Center of which Circle would be then before them, and this, without turning their Bodies round about.

Solution.

They muſt firſt form themſelves into a Circle, at the South Pole, the Center of which will be behind every Man, and when they have travelled 5400 Miles, they will come to the Equator, where they will be ſideways to each other, at 300 Miles diſtant, the Center of which Circle will then be directly under them in the Center of the Earth: and when they have travelled 5400 Miles more, they will all meet again, with their Faces inward, at the North Pole, and conſequently the Center of that Circle muſt be before them.

PARADOX XXVII.

There is a certain famous Church in the Kingdom of *England*, which is ſituated in ſuch a ſtrange Manner, that, when a Man has travelled 80, 90, or 100 Miles regularly, he ſhall be neither nearer to it, nor farther from it, then he was at the firſt Minute that he began that Journey.

Solution.

This may be any Church, ſuppoſe St. *Paul's*, at *London*, from which, if a Man begin to travel at any convenient Diſtance, and go the juſt mentioned Number of Miles, or any greater Number, and travel in a Circle, reſpecting that Church as the Center of it, he muſt, all the Way, keep the ſame Diſtance; and in conſequence thereof, be neither nearer to it, nor farther from it, than he was the firſt Minute he began his Journey.

2. *PHILOSOPHICAL PARADOXES.*

PARADOX XXVIII.

There is a certain Place of the Earth, at which, if two Men ſhould chance to meet, one would ſtand upright upon the Soles of the others Feet, and neither of them would feel the other's Weight; and yet they would both retain their natural Poſture.

Solution.

This Place is the Center of the Earth, beyond which nothing can go. For as every Thing has a tendency to its own Center; when once it arrives there, that is its reſting Place: Therefore, if two Men, at any ſuch Sides of the Globe of the Earth, as are dimetrically oppoſite, were *gradually*

dually let down, till they reached the Center of the Earth, they would meet Feet to Feet exactly, and there reſt, without oppreſſing each other; and each would retain his natural Poſition, juſt the ſame as when he ſtood upon the Surface of it.

Note, A Body may paſs the Center, if let fall, becauſe it will have acquired Velocity; but then, by the Power of Gravity, it will be retarded, and brought back again, and will continue to vibrate, like a String and Ball, upon a Pin, until it ſettles and reſts ſuſpended in the Center.

PARADOX XXIX.

There is a certain Place of the Earth, where a Fire being made, neither Flame, nor Smoke would aſcend, but move circularly about the Fire.—Moreover, if in that Place one ſhould fix a ſmooth plane Table, without any Ledge whatever, and pour thereon a large Quantity of Water, not one Drop thereof would run over the ſaid Table, but would raiſe itſelf up in an Heap.

Solution.

This Place (like the former) is the Center of the Earth; from whence the Smoke and Flame could not aſcend, but muſt move circularly round about the Fire, and perhaps extinguiſh it again; there being at that Point no Line of direction, from whence the Smoke and Flame might paſs.—Alſo,

If a plane Table (that is the upper Part, without Legs or Feet) were fixed there, and the Center of the Table coincided with the Center of the Earth, and alſo, if Water was brought there, it would run to the Center of the ſaid Table, and riſe in an Heap, but not a ſingle Drop would run off.

PARADOX XXX.

There is a certain Iſland in the *Ægean* Sea, upon which, if two Children were brought forth, at the ſame Inſtant of Time, and living together for ſeveral Years, ſhould both expire on the ſame Day, yea, at the ſame Hour and Minute of that Day, yet the Life of one would ſurpaſs the Life of the other, by ſeveral Months.

Note, The *Ægean* Sea, is that Part of the *Mediterranean*, near *Greece*, commonly called the *Archipelago*.

Solution.

The Reaſon of this is founded on two Sorts of People living upon that Iſland at the ſame Time, *viz.* *Chriſtians* and *Mahometans*, who keep their Accounts of Time different from each other. The *Chriſtians* Year is from the Sun's departing from any one Point in the Heavens (*viz.* firſt Point of ♈) to its return to that Point again, which is called a *Solar Year*, conſiſting of 365 Days, 6 Hours, nearly: The *Turks* or *Mahometans*, uſe a *Lunar Year*, conſiſting of 354 Days. Now, if one Child is born of *Chriſtian* Parents, and another of *Turkiſh* Parents, tho' at the ſame inſtant of

Time, yet if they live together 40 or 50 Years, and both expire at the ſame Hour and Minute of the ſame Day, the Life of one, that is, the *Turkiſh* Child, would ſurpaſs the Life of the *Chriſtian* Child, by ſeveral Months, becauſe the *Turkiſh* Year being ſhorter by 11 Days, than the *Chriſtian* Year, the *Turkiſh* Child would live more Months, according to the *Mahometans* than the *Chriſtian* Child according to the *Chriſtians*; ſuppoſing, in this Caſe, the *Mahometans* uſe no intercalary Months to make up the *Solar* Time.

Note 1. This *Paradox* may be ſolved thus: Suppoſe two Children born at the ſame Time, and Place, and living ſeveral Years together, they afterwards travel round the World, one Eaſt, the other Weſt conſtantly for ſeveral Years, until their Deaths, at the ſame Inſtant of Time: Should they travel round once every Year, there wou'd ariſe two Days difference every Year, or in 30 Years, 60 Days.

2. I have ſeen another *Solution* to this *Paradox*, but think it a little too foreign.— See, Price on the *Globes*, *Paradox* 8, p. 132.

PARADOX XXXI.

There are two obſervable Places belonging to *Aſia*, that lie under the ſame Meridian, and at a ſmall Diſtance from one another, and yet the reſpective Inhabitants of them, in reckoning their Time, do differ an entire natural Day, every Week.

Solution.

The Places are out of the Queſtion; for they may be, and are in fact, in *England*; and even in every Town, where *Chriſtians* and *Jews* live together. The Difference of Time therefore is concerning the Sabbath, which the *Jews* keep every ſeventh Day, and the *Chriſtians* every firſt Day of the Week.

PARADOX XXXII.

There is a remarkable Place of the Earth, of a very pure and wholeſome Air to breathe in, yet of ſuch a ſtrange and deteſtable Quality, that it is abſolutely impoſſible for two of the ſincereſt Friends that ever breathed, to continue in the ſame in mutual Love and Friendſhip, for the Space of two Minutes of Time.

Solution.

The ſame Place, be it where it will, can never be poſſeſſed by two Perſons at the ſame Time. Hence it naturally follows, that whatever Place any one Perſon ſtands upon, if another would ſtand on the ſame Place, or Spot of Ground, he muſt either thruſt away the Perſon who ſtands upon it, or be thruſt away himſelf; and this breeds Contention; and where Contention is, there can be no mutual Love and Friendſhip. However, this Contention is not to be taken in the worſt ſenſe, as if it would breed Hatred and Malice: for this Contention may be between two Friends; and if they contend ever ſo long, yet ſtill the *Paradox* holds good, that no two Perſons can poſſeſs the ſame Spot of Ground at one and the ſame Time.

PARADOX XXXIII.

There are divers noted Places on the Globe of the Earth, whoſe ſenſible Horizon is commonly fair and ſerene, and yet its impoſſible therein to diſtinguiſh properly any one of the intermediate Points of the Compaſs; or ſo much as two of the four Cardinal Points.

Solution.

This may be underſtood two Ways.

1. However, fair and ſerene the ſenſible Horizon may be in any Place, yet it is certainly impoſſible to diſtinguiſh properly any one Point of the Compaſs, whether intermediate or Cardinal, becauſe they were never wrote or deſcribed there.

2. The noted Places, abovementioned, may be at the two Poles, where let a Perſon turn himſelf which Way he will, at the North Pole he muſt always face the South, and at the South Pole always face the North; and therefore it is impoſſible, in that Situation to diſtinguiſh any one intermediate Point, or two Cardinals, there being only one.

PARADOX XXXIV.

There is a certain Iſland in the *Baltic* Sea, to whoſe Inhabitants the Body of the Sun is clearly Viſible in the Morning before he riſeth, and likewiſe in the Evening after he ſets.

Solution.

This is equally true in every Place to the Northward of *London*, where the *Refractions* increaſe, as well as in the *Baltic* Sea, and the nearer to the North Pole, the greater the *Refraction*: For by the *Refraction* of the *Atmoſphere*, the whole Body of the Sun is always ſeen before he riſes, if the Horizon be clear; and is likewiſe ſeen after he is totally ſet. But towards the Equator, the *Refraction* leſſens, and then only Part of the Sun is ſeen, becauſe the *Refraction* is leſs than the Sun's mean Diameter. See, *Theorem* XIII.

PARADOX XXXV.

There is a large Country in upper *Ethiopia*, to whoſe Inhabitants the Body of the Moon doth always appear to be moſt enlightened, when ſhe is really leaſt enlightened; and to be leaſt enlightened, when ſhe is really moſt ſo.

Solution.

The Moon running always round the Earth, and both together round the Sun, makes it that ſhe is ſometimes between the Sun and the Earth, and ſometimes the Earth is between the Sun and her: In conſequence of which, when the Earth is between the Sun and the Moon, it is full Moon; at which Time ſhe appears to be moſt enlightened, when, in reality, ſhe is leaſt ſo, becauſe ſhe is then fartheſt from the Sun: And, when the

Moon comes between the Sun and the Earth, it is New Moon, at which Time ſhe appears to be leaſt enlightened, when in reality ſhe is moſt ſo, becauſe ſhe is then neareſt to him, only we can't ſee the enlightened Part, that being turned towards the Sun; and this, not only in *Ethiopia*, but in every Part of the World. And as Light being received on any thing from a luminons Body is always in a duplicate *Ratio* of the Diſtance of the enlightened Body from the luminous one, it muſt be, that the farther the Moon is from the Sun, ſhe muſt be leaſt enlightened, and the nearer ſhe is to it, ſhe muſt be the moſt enlightened. The Truth of this will be evident in a great Degree, from a Room being enlightened by a ſingle Candle: If any thing be held near it, the Light will be ſtrongly reflected; but, if it be held conſiderably farther off, the reflected Light will be the ſmaller.

PALADOX XXXVI.

There is a certain Iſland, whereof mention is made by ſeveral of our lateſt *Geographers*, whoſe Inhabitants cannot properly be reckoned either *Male* or *Female*, nor altogether *Hermophradites*; yet ſuch is their peculiar Quality, that they are ſeldom liable to either *Hunger* or *Thirſt*, *Cold* or *Heat*, *Joy* or *Sorrow*, *Hopes* or *Fears*, or any ſuch of the common Attendants of *Human* Life.

Solution.

This can be underſtood no otherwiſe than of an Iſland, having neither human, animal, or reptile Species upon it; nor Fiſhes in its Rivers, Streams or Lakes; and then its Inhabitants can only be ſuch things as ſpring out of the Ground, ſuch as Trees, Shrubs, or any thing elſe of the Vegetable kind, which can never be liable to *Hunger* or *Thirſt*; *Cold* or *Heat*, *Joy* or *Sorrow*, *Hopes* or *Fears*; nor to any other of the common Attendants of human Life.

PARADOX XXXVII.

There is a certain Place on the Continent of *Europe*, where, if ſeveral of the ableſt Aſtronomers, that the World now affords, ſhould *nicely* obſerve the *Celeſtial Bodies*, and all, at the very ſame Time, yet, the Planetary Phaſes, and their various Aſpects, would be really different to each of them.

Solution.

This *Paradox* has been anſwered by another Hand, in the following Manner, thus; "Neither at the Center, or any Part of the Earth, no one can obſerve all the *Celeſtial Bodies*, at one and the ſame Inſtant of Time, and conſequently will appear different, becauſe they are conſtantly in Motion". But from the Nature of the *Paradox*, this *Solution* is too obſcure to be admitted as ſuch: For, if it be granted, that no two Perſons can ſtand in the ſelf-ſame Place, at one and the ſame Time, as at *Paradox* XXXII, the *Celeſtial Bodies*, can never be *nicely* obſerved, by a large Number; becauſe, by endeavouring to obſerve on the ſame Spot at once, at once, there muſt be a great deal of Confuſion; and the word *all*, as I underſtand it, means not *all* the *Celeſtial Bodies*, but all the *Aſtronomers* then obſerving: Hence, I would offer the following *Solution.*

As no two Men taſte, ſmell, hear, or feel alike; ſo no two Men ſee alike; nay, even a ſingle Man's own two Eyes don't ſee alike, for (the Experiment is very eaſy) let him but ſhut one Eye and ſee with the other, and the contrary, and he will preſently confeſs it. If this be granted, it will be eaſy to conceive, that the Planetary Phaſes may be really different to each of them, ſuppoſing it to be in Magnitude only, becauſe they may appear greater or leſs to one Man than to another; it being pretty evident, that ſome Men have more microſcopial Eyes, and can diſcern diſtinctly and clearly almoſt the minuteſt Objects, than others who can ſcarcely ſee them at all.

PARADOX XXXVIII.

There is a large and famous Country in the Continent of *Africa*, many of whoſe Inhabitants are born perfectly Deaf, and others quite Blind; and continue ſo their whole Lives: And ſuch is the amazing Faculty of thoſe Perſons, that the Deaf are as capable to judge of Sounds as thoſe that hear; and the blind of Colours, as they who ſee.

Solution.

It is now beyond diſpute, that Perſons born Blind, or having loſt their Sight very early, are able to judge of Colours, ſince Dr. *Sonderſon*, late Profeſſor of Mathematics, at the Univerſity of *Cambridge* (who loſt his Sight by the Small Pox, when he was very Young) has made it appear very evidently, that, in his Mind, he could do ſo, tho' by the Touch he could not do it; and declared, that all ſuch Perſons as pretended to it, only pretended to Impoſſibilities. What Ideas Perſons born Deaf may have of Sounds is hard to ſay (admitting it poſſible that they may have ſome) becauſe they are unable to communicate them by Speech themſelves, they being denied that Faculty; and they are altogether as unable to do it by Writing, becauſe there is no communicating to them any thing belonging to the Force or Sound of Letters, they being denied the Faculty of Hearing. Hence, by the Way, Deaf Perſons can no more be taught to Read than they can be taught to Speak: And being unable either to Speak or Write intelligibly, we are therefore unable to judge of their Ideas of Sound: Hence alſo, the latter Part of this *Paradox* cannot be cleared up. It was owing to *this*, that this *Paradox* was but half anſwered elſewhere, *viz.* Price on the *Globes*. *Paradox* XXIX, page 144, when it was ſaid, that the Blind and Deaf have Capacity to judge of Colours, as they who ſee and hear; omitting the deaf Man's Judgment of Sounds.

PARADOX XXXIX.

There are certain People in *South America*, who are furniſhed with only one of the five Senſes, *viz.* that of *Touching*; and yet they can both hear and ſee, taſte and ſmell, and that as *nicely* as we *Europeans*, who have all the five.

Solution.

All the Senſes are, in fact, reduced to one called the *Touch.* It is impoſſible to hear diſtinctly, except the Sound touch the *Tympanum*, or as ſome call it, the Drum of the Ear: No body can *ſee*, if the Object does not firſt ſtrike the *Ratina*, or fine Net-work behind the Eye. *Taſte* is nothing, if the thing to be taſted does not firſt touch the Tongue or Palate. Nor can any one *Smell*, except the Scent, whether pleaſant or unpleaſant, firſt touches the *olfactory* Nerves of the Noſe: Thus all the five Senſes being reduced to one, called the Touch, not only the People in *South America*, but in all the World, may be ſaid to have only that one of the five Senſes, called the *Touch*.

PARADOX XL.

There is a certain Country in *South America*, many of whoſe Savage Inhabitants are ſuch unheard of Canibals, that they not only feed upon human Fleſh, but alſo ſome of them do actually eat *themſelves*, and yet they commonly ſurvive that ſtrange Repaſt.

Solution.

The Difficulty of this *Paradox*, conſiſts in the Word *themſelves*, but with a little Conſideration, and Tranſpoſition, it will be underſtood, that Canibals themſelves do actually eat as other Men do, each one for himſelf; and in this Manner it is to be underſtood, that they eat themſelves; but not that each Man devours his own Fleſh.

PARADOX XLI.

There is a certain great Circle paſſing round the Globe of the Earth, on which, if a Man travel quite round, his Head will abſolutely go faſter than his Feet, and yet both of them retain their natural Poſition.

Solution.

This is true on any Meridian, or upon the Equator, or any other great Circle. For as Circles, the more remote they are from their Center, are bigger and bigger; ſo the Head, in travelling, making a larger Circle than the Feet, muſt go faſter. Juſt as a Wheel, whoſe outer Rim is farther from its Center than the Nave, in every Rotation, the whole turns round at one and the ſame Time exactly, and yet the Rim of it paſſes much ſwifter than any Part of the Nave, becauſe it is much larger. If it be ſaid that the outward Rim of a Wheel is abundantly more diſtant from the Center than the Nave, and that a Man's Head is ſo very little more diſtant from the Center of the Earth than his Heels, and therefore the Proportion is next to nothing, it is granted; but ſtill there is a Proportion, tho' very ſmall, and while that Proportion remains, ſmall as it is, it muſt hold good, that while a Man is walking, on any great Circle, his Head will move faſter than his Heels.

PARADOX XLII.

There are ſeveral Tracts of Land very near *London*, each of which is not above 20 Feet over, meaſured any Way; and yet a Horſe may travel on either of them, very regularly 30 Miles per Day: Moreover (ſuch is the Situation of them) the ſame Horſe, while his off Legs, *i. e.* right Legs, go the ſaid 30 Miles, his near Legs, *i. e.* left Legs, will unavoidably go nearly 31 Miles in the ſame Time; the Horſe being all the while ſound and in juſt Proportion.

Solution.

The Horſe muſt be put in a Mill, where he will travel in a Circle, without any Impediment: And as Circles, the nearer they are to their Center, the ſmaller they be; ſo the off Legs making a ſmaller Circle than the near Legs, muſt travel leſs Ground.

Note, The Drivers of Horſes go generally on the left Side; hence, the left Side is called the near Side, and the right the off Side.

PARADOX XLIII.

There is a large and ſpacious Plane in a certain Country of *Aſia*, able to contain 600000 Men, drawn up in Battle Array, which Number of Men being actually brought thither, and there drawn up, it is abſolutely impoſſible for any more than one ſingle Perſon to ſtand upright upon the ſaid Plane.

Solution.

The whole Globe of the Earth, making one complete Circle, which way ſoever it be meaſured, ſo it be done upon a great Circle, any Part thereof muſt be circular too, and ſuch muſt be the abovementioned Plane. Hence it follows, that no two Men can be parallel to each other, but their Heels will be nearer to each other than their Heads. And tho' this is not perceptible to the Eye, yet it muſt hold good in a ſmaller Quantity, as well as in a larger one; which evidently appears from right Lines drawn from the Center of a Circle to the Periphery, where it may be obſerved, that the farther they advance, the more diſtant they are, and conſequently cannot be parallel to each other. And ſo it is with regard to any Body of Men drawn together, any one of which ſtands upright to himſelf only, and all the reſt are to him in a ſloping Poſition, becauſe not parallel to each other.

PARADOX XLIV.

There is a certain *European* City, whoſe Buildings being generally of firm Stone, are, for the moſt Part, of a prodigious Height, and exceeding ſtrong; and yet it is moſt certain, that the Walls of thoſe Buildings are not parallel to one another, nor perpendicular to the Plane on which they are built.

Solution.

From what has been ſaid in the *Solution* of the preceding *Paradox*, it will be eaſy to conceive, that any two Walls, how ſtrong ſoever, if built according to Art, cannot be parallel to each other, but the higher they go, the more they ſeparate, conſequently the lower or deeper they go, the more they incline; and if Lines were drawn from them ſtill farther downward, they would at laſt meet in a Point in the Center of the Earth: Neither are they perpendicular to the ſuppoſed Plane on which they are built; becauſe that Plane is every Way curving, and a Perpendicular can be raiſed only from a ſingle Point on an Horizontal Plane.

PARADOX XLV.

There is a certain City on the Southern Part of *China*, whoſe Inhabitants, both Male and Female, do obſerve almoſt the ſame Poſture and Gait in walking as we *Europeans*; and yet they frequently appear to Strangers, as if they walked on their Heads.

Solution.

There is no more in this *Paradox*, than that, if the *Chineſe* walk cloſe by a River or Pond, they appear, not only to Strangers, but Natives alſo, who are on the other Side, with their Heads downward, by the Reflection in the Water; and thus it is that they appear, as if they walked on their Heads. The ſame may be ſaid of all other Perſons, in any other oppoſite Part of the World.

3. *ASTRONOMICAL PARADOXES.*

PARADOX XLVI.

There is a conſiderable Number of Places within the *torrid Zone*, in any of which, if a certain kind of Sun-dial be duly erected, the Shadow will go back ſeveral Degrees upon the ſame, at a certain Time of the Year, and twice every Day, for the Space of divers Weeks: Yet no Ways derogating from that miraculous returning of the Shadow, upon the Dial of *Ahaz*, in the Days of King *Hezekiah*.

Solution.

If, by the Shadow's going backward twice every Day, be underſtood the Sun's appearing twice upon the ſame Azimuth, as at *Problem* XLVII, (if it be duly attended to) that *Problem* will ſufficiently clear up this *Paradox:* But if, by the Shadow's going backward be underſtood a retrograde Motion, with regard to the Hours marked on the Sun-dial, the following *Explication* will clear it up. In the firſt, the Sun muſt be in the *torrid Zone*, and the Sun's Declination greater than the Latitude, as in the forementioned *Problem*; in the ſecond, the Place may be out of the *torrid Zone*, and then the Latitude muſt be greater than the Declination, becauſe it cannot be otherwiſe; and by how much the Latitude of the Place is greater than the Sun's Declination, the more conſpicuous is the Appearance. In all Reſpects an Equinoctial Dial muſt be uſed, and figured as *Plate* 2. *Fig.* 1. and we will ſuppoſe it to be uſed in the Lat. of 51° 32′ N.

Now if this Dial be doubled, or made the ſame on both Sides; that is, one Side exactly anſwering to the other, as above, with a double Gnomon, and be made to recline according to the given Latitude, it will exhibit, as follows; *viz.*

1. At the Sun-riſing, the lower Side will receive the Sun firſt, and then the Shadow will run Weſtward; and the more the Sun advances, the further will the Shadow of the Gnomon extend, and according to the Figures thereon, will run backward, till the Sun leaves that Side, which will be about 6 A. M.

2. The upper Side will next receive the Sun, and then the Shadow of that Gnomon will move juſt contrary and run Eaſtward, ſhortening till Noon, and then lengthening again till about 6 P. M. at which Time,

3. The lower Side will again receive the Sun, when the Shadow of its Gnomon (tho' it is Eaſterly) will ſhorten and move toward the Weſt, till the Sun ſets; and ſo it will (according to the Figures) move backward that Way too.

This will be done twice every Day, till the Sun's Declination is ſuch, that it will ſhine only on one Side, and then there is an End of the *Paradox.*

As to the Number of Places, they may be as many as you pleaſe, but they muſt be all of them in the ſame Parallel of Latitude, or near it; and the Time of the Year, when this can be beſt effected, will be, when the Sun is near either of the Tropics (as in North Latitude, when he is near the Tropic of ♋) whether before or after his arrival there. Neither will this derogate from the miraculous returning of the Shadow on the Dial of *Ahaz:* For tho' this is not a Miracle like that, yet here is a going backward of the Shadow, firſt on the lower Side, when the Extremity of the Shadow in the Morning, not only runs from the Sun, but runs backward, according to the Hours; and ſecondly, on the upper Side, when it meets the Sun in the Morning, and in the Afternoon goes from him again: And laſtly, when the Extremity of the Shadow on the lower Side again (tho' it tends Eaſtward, yet) inclines toward the Sun, but yet goes backward, with reſpect to the Hours.

Add to this, that the Miracle was not really wrought upon the Dial of *Ahaz,* but in the Earth's turning backward, or from Eaſt to Weſt upon its own Axis, contrary to its natural Motion from Weſt to Eaſt, and this muſt neceſſarily occaſion the Sun to be raiſed higher above the Weſtern Horizon, than it was immediately before the Miracle happened: I ſay Weſtern Horizon, becauſe it appears by ſacred Writ, that the Sun had paſſed the Meridian of that Place, and was going down upon the Dial of *Ahaz:* And as the Sun was again raiſed by the inverted Motion of the Earth; ſo the Shadow muſt in Courſe go backward, according to the Degrees on the ſaid Dial; tho' the Motion, in all probability, was very ſudden and ſwift; but whether the inverted Motion of the Earth was ſwift or ſlow, is a Point, that has never yet been diſcuſſed, much leſs cleared up.

Note, It would not be amiſs, if the Tutor would make an Equinoctial Dial, upon Paſteboard, on both Sides, and cauſe the Gnomon (to be made of Paſteboard likewiſe) to paſs thro' the middle of the Dial, by which means the Pupil would underſtand this *Paradox* the better.

To make an Equinoctial SUN-DIAL.

1. Draw A B for the horizontal Line of the Plane.
2. Biſext it in the Point Q.
3. Draw 12 Q 12 for the Meridian, Hour-line of 12 and Subtile.
4. On 12 Q 12 aſſume a Point at Pleaſure, as S.
5. On S, with a convenient opening of your Compaſſes, deſcribe a Semicircle C D E.
6. Divide the Semicircle into 12 equal Parts.
7. Lay a Ruler on S, and the ſeveral Points ⊙⊙⊙, and it will cut A B in ✱✱✱.
8. Thro' ✱✱✱ draw Lines parallel to 12 Q 12 for the Forenoon, and Afternoon Hours.
9. Make the Hours, and erect the Stile, whoſe Height muſt be = 12 and 3, and thus is the Dial finiſhed.

PARADOX XLVII.

There is a certain Village in the Kingdom of *Naples*, ſituated in a very low Vally, and yet the Sun is nearer to the Inhabitants thereof, every Noon, by 3000 Miles and upwards, than, when he either riſeth or ſetteth to thoſe of the ſaid Village.

Solution.

This is alſo true in every Place, as well as at, or near *Naples*; it being known by Obſervation, that the Sun is nearer to any Place, by the Earth's Semidiameter, or nearly ſo, when he is on the Meridian of that Place, than at the Time of his Riſing and Setting. As to the Depth of the Vally, it is very inconſiderable, compared to the Semidiameter of the Earth, which is upwards of 3000 Miles.

PARADOX XLVIII.

There is a certain Hill in the South of *Bohemia*, on whoſe Top, if an Equinoctial Sun-dial be duly erected, a Man, ſtone Blind, may know the Hour of the Day by the ſame, if the Sun ſhines.

Solution.

This may be effected as well in a Vally as upon a Hill, and in *England*, or any other Place, as well as in *Bohemia*: But there muſt be a particular Style for that Dial, and the Hours on the Dial, muſt alſo be very deeply engraven upon, or be raiſed above the Plane of it; and then, if a burning Glaſs be admitted for the Style, the *Focus* of which ſhall fall upon the Hour, it will ſo heat that Part, that a blind Man may very well diſcover the Hour, he being beforehand made ſenſible of the Nature of ſuch a Dial.

PARADOX XLIX.

There is a certain Village in the South of *Great-Britain*, to whoſe Inhabitants the Body of the Sun is leſs Viſible, about the Winter Solſtice, than to thoſe who live upon the Iſland of *Iceland*.

Solution.

In what Part ſoever of *Great-Britain* this Village is ſituated, it matters not: But if the Village be at the Bottom of, and on the North-ſide of a Hill, and that Hill be very high, and of any conſiderable Length, the Sun will not only riſe later, and ſet ſooner at that Place; but alſo be nearer the ſenſible Horizon of it, at the Winter Solſtice, than in any Part of *Iceland* upon level Ground; and conſequently the Sun will be leſs Viſible to the Inhabitants of that Place; that is, will be ſeen a ſhorter Time than in *Iceland*. Or the Height of an Hill may be ſuch, at that Time of the Year, which is Mid-Winter, as wholly to intercept the Sun for ſeveral Days.

PARADOX L.

There is a remarkable Place on the Earth, of a conſiderable Southern Latitude, from whoſe Meridian the Sun removeth not for ſeveral Days, at a certain Time of the Year.

Solution.

This is at the South Pole, where the Sun, when he is above the Horizon of that Place is always full North. For, as at the South Pole, let a Man turn himſelf which Way he will, he will always face the North: So for the ſame Reaſon, the North is the Meridian of the South Pole.—— Hence the Sun, when he is above the Horizon of the South Pole, departs not from the Meridian of that Place for half a Year, but during that Time is always due North.

Note, The like may be ſaid at the North Pole, where the Sun is always due South.

PARADOX LI.

There is a certain Place on the Earth, of a conſiderable Northern Latitude, where, tho' the Days and Nights, even when ſhorteſt, do conſiſt of ſeveral Hours; yet in that Place it is Mid-day or Noon every Quarter of an Hour.

Solution.

This is at the North Pole. And for the like Reaſon, in the laſt mentioned *Paradox*, that the Sun, to the Inhabitants at the South Pole, was always upon the Meridian during his ſtay above the Horizon of that Place: So for the ſame Reaſon, when the Sun is above the Horizon to the Inhabitants at the North Pole, he is always due South, and conſequently it muſt be Noon-day not only every Quarter of an Hour, but every Minute.

PARADOX LII.

There are divers Places on the Earth, where the Sun, Moon, and all the Planets, do actually riſe and ſet, according to their various Motions, but never any of the fixed Stars.

Solution.

At the two Poles, the Sun, Moon, and all the Planets do actually riſe and ſet, according to their various Motions; but the fixed Stars neither riſe nor ſet, becauſe their Appearances are always the ſame.

Note, Tho' this holds good upon the artificial Globe, yet upon the natural Globe, it is not ſtrictly true. For, by the Regreſs of the Equinoctial Points, the Declination of the Stars alter; and that which is now the North Pole Star, will be to the Southward of the Zenith of *London*, in about 12000 Years.

PARADOX LIII.

There is a very remarkable Place on the Globe, where all the Planets, notwithſtanding their different Motions and Aſpects, do always bear upon one and the ſame Point of the Compaſs.

Solution.

At the North Pole, the Planets always bear due South; and at the South Pole, they always bear due North.

PARADOX LIV.

There is a certain noted Place upon the terraqueous Globe, where the Sun, and Moon at full, may both happen to riſe at the ſame Time, and upon the ſame Point of the Compaſs.

Solution.

This happens at the North Pole, when the Sun enters ♈; and at the South Pole when he enters ♎; at both which Times, when a full Moon happens, tho' they both riſe on oppoſite Sides of the Horizon; *i. e.* in the Equinoctial Points, yet they are both upon the ſame Point of the Compaſs; *i. e.* at the North Pole full South, and at the South Pole full North.

PARADOX LV.

There is a certain Place in the Iſland of *Great-Britain*, where the Stars are always Viſible at any Time of the Day, if the Horizon be not overcaſt with Clouds.

Solution.

This is in the Royal Obſervatory at *Greenwich*, or at any other Place, where there is a deep dry Well, made on Purpoſe to obſerve the Stars in the Day Time; by which it can be known what Stars come to the Zenith at Noon-at Noon-Day: For the ſur-rounding Light, which the Atmoſphere ſpreads in the open Air, not preſſing upon the Sight, the Eye, in that Place is in total Darkneſs; by the Means of which (when there are no Clouds in the Air, and the Air itſelf quite clear) they can be ſeen in the Day-time, as well as at Night.

PARADOX LVI.

There are ſeveral Places on the Globe, where the Sun is ſeveral Times upon the ſame Point of the Compaſs in the Forenoon, and in the Afternoon.

Solution.

Any where on the Equator, when the Sun is in the Equinoctial, he may be ſaid to be due Eaſt, at every Hour before Noon, and due Weſt every Hour after Noon. Or, at any Place, where the Declination is greater than the Latitude, the Sun will be upon the ſame vertical Circle, twice in the Morning, and twice in the Afternoon. See Page 71, *Prob.* LXV, aforegoing.

A new and complete

DESCRIPTION

Of the Terreſtrial and Celeſtial

GLOBES,

With their ſeveral Uſes.

PART VII.

Containing the Uſe of the Celeſtial GLOBE, exemplified in 26 *Problems*, with a further Deſcription of the ſame, and a ſhort Account of the *Copernican* Syſtem.

As the Terreſtrial *Globe* has the Forms, Boundaries, and Situations of the ſeveral Kingdoms, Empires, Iſlands, Oceans, Seas, Bays, Lakes, &c. of the whole Body of the Earth and Water marked on it: So the Celeſtial *Globe* has on it, the ſeveral fixed Stars diſtinguiſhed by their ſeveral Magnitudes, as come within the Compaſs of our Obſervation, and alſo placed in ſuch Forms, and at ſuch Diſtances from each other, as if they appeared to us in one continued Plane in the open Face of the Heavens, when viewed in a clear Night without the Moon; but with theſe two Differences; *viz.*

1. That the Spectator, when he obſerves the ſtarry Orb, conceives himſelf in the midſt of a vaſt Concave, or hollow Expanſe; and when he obſerves the Stars on the artificial celeſtial *Globe*, imagins himſelf on the out-ſide of them. And,

2. That whatever Appearances the natural Stars make with regard to right Hand and left, the artificial ones appear juſt the contrary. And therefore in order to help the Learner in this ſeeming Difficulty, and rectify ſuch Contrariety in Appearance, let him

(1.) Imagin himſelf ſituated beyond or without-ſide the natural Orbs of the Stars, and then they will appear to him juſt as they do on the artificial celeſtial *Globe*. Or,

(2.) Let him imagin the celeſtial *Globe* to be tranſparent, and that himſelf were ſeated in the middle of it, and then the artificial Stars that are thereon, will appear in juſt the ſame Situation as the natural ones do.

Either of theſe Ways, according to the Pupil's Conception of them, will anſwer the End deſigned, by aſſiſting him in the *Solution* of the following *Problems*.

But before I proceed to them, it will be neceſſary to premiſe ſomething concerning the *Pythagorean* or *Copernican* Syſtem, as it is now called, which is univerſally received at this Time, and has been for a good many Years, as well as give a further Account of the fixed Stars themſelves; by which Means a Way will be paved for the Pupil's better underſtanding the following *Problems*.

Of the *COPERNICAN* SYSTEM.

The preſent Syſtem of the Univerſe is an Improvement of that, which (as far as we can tell) firſt obtained in the World; no other prior to that being known. Its firſt Inventor we are ignorant of; however, as it was maintained and cultivated by *Pythagoras*, a learned *Philoſopher* of *Samos*, and his *Diſciples*, who flouriſhed about 500 Years before *Chriſt*, it was then, and afterwards called the *Pythagorean* Syſtem. See *Plate* 3. *Fig*. 1.

This Syſtem, good as it was, at that Time, was laid aſide for another invented, or as ſome affirm, only maintained and illuſtrated by *Ptolemæus*, *Alexandrinus*, a great *Aſtronomer* and *Geographer* of *Alexandria* in *Egypt*, called the *Ptolemaic* Syſtem, about the Year of *Chriſt* 140, and gained ſo much Credit, that at laſt the *Pythagorean* Syſtem was intirely laid aſide and forgot. See *Plate* 3. *Fig*. 2.

Note, His proper Name is *Claudius Ptolomæus*, and was born at *Peluſium*, in *Egypt*; ſuppoſed to be deſcended from the *Ptolomies*, Kings of *Egypt*. He did not invent this Spſtem, but made alterations in the old *Egyptian* Syſtem, which Syſtem prevailed over the philoſophic Opinions of *Thales*, *Anexagoras*, *Pythagoras*. and *Philolaus*, that the Sun was the Center. By ſome he may be ſtiled under the Epithet of *Alexandrinus*, from that more noted City; but ſtrictly he is *Peluſianus*.

But *Nicholaus Copernicus*, a famous *Aſtronomer* of *Poliſh Pruſſia*, finding the Mathematicians of his Time very unſettled in their Opinions, and unable to make any ſolid Determinations about the heavenly Bodies, was reſolved to ſet about it himſelf; and conſidering the old *Pythagorean* Syſtem, and examining it very carefully, found it to be moſt agreeable to the Motions of the heavenly Bodies, beyond that of *Ptolemy*, at leaſt ſo far as the Strength of human Reaſon was able to prenetrate, and accordingly, about the Year of *Chriſt* 1543 (as appears by the *Chronology* of *Chriſtophorus Helvicns*) made it known to the World, which overſet the *Ptolomaic* Syſtem; and as it was embraced by ſome of the then and ſucceeding Mathematicians, it was, and is now called the *Copernican* Syſtem.

Note 1. Mr. *William Leyborn*, who publiſhed his *Curſus Mathematicus* in 1690, ſays (page 433.) This Syſtem, about two Ages ſince, was reſuſcitated from Oblivion and the Grave, by Cardinal *Caſanus*, but imperfectly, until *Copernicus* came, and gave it a perfect Conſummation. And then,

2. Not all the Mathematicians embraced it by far; it was by a few: The Number encreaſed but ſlowly, until *Galileo's* Time, about the Year 1600. For in the Year 1610, he diſcovered the Solar Spots; and from thence, that the Sun moved upon his Axis; publiſhed his Principles; aſſerted the Motion of the Earth, and that the Sun was the Center: For this, he was charged by the Church, with a damnable Hereſy, and Condemned, but recanted to ſave his Life, *June* 22*d*, 1633, in the 70*th* Year of his Age.

3. The Satellites of *Jupiter*, were firſt diſcovered by the abovementioned *Galileo*, and *Saturn's* by *Caſini*, after *Galileo* ſome Time. The Ancients obſerved Comets, but were much divided, and did not know what to make of them: Nor, were their Orbits rightly defined, until Sir *Iſaac Newton* did it for them.

There was another Syſtem, about the Year 1580, publiſhed by *Tycho Brake*, a Nobleman of *Denmark*; but as it was not, upon Examination, founded upon ſuch juſt Reaſons, as the *Copernican* Syſtem was, it had ſome Admirers, but not Credit enough to make its Way into the World, ſo as to be generally received, and therefore it was at laſt totally rejected. See *Plate* 3. *Fig.* 3.

The *Copernican* Syſtem, ſuppoſes the Sun to be in or near the Center of the Orbs revolving about him.

Next is *Mercury*; then *Venus*; the *Earth*; *Mars*; *Jupiter* and *Saturn*; all theſe, except the Sun, are called Planets.

The Sun has only a central Motion; *i. e.* turns round its own Axis, from Eaſt to Weſt.

Note 1. The Maculæ Solares, or Spots in the Sun (firſt obſerved by *Galileo*) determin this Motion, becauſe they are ſeen to move from the Eaſtern to the Weſtern Limb.

2. Theſe Maculæ Solares, when they arrive at the Weſtern Limb of the Sun, and then diſappear, muſt ariſe from their being then on the other Side of the Sun, and ſo moving on till they arrive at the Eaſtern Limb again: Hence, the Sun may alſo be ſaid to turn upon its own Axis from Weſt to Eaſt: And this will evidently appear from any Ball being made to turn upon its own Axis: for, if the Side next you turn from Eaſt to Weſt, the oppoſite Side muſt turn from Weſt to Eaſt.

All the Planets move round the Sun in elliptical Forms from Weſt to Eaſt in their direct Motions, but in their retrograde Motions from Eaſt to Weſt. They have alſo, at the ſame Time, a central Motion on their own Axes from Eaſt to Weſt, like to that of the Sun.

Note, Tho' *Mercury* from its vicinity to the Sun, and *Saturn* from its extream Diſtance, cannot be perceived to have any central Motion, yet there is all the Reaſon imaginable to think that they are not quieſcent in that Reſpect any more than the Reſt.

Mercury and *Venus* are called inferior Planets, from their moving in leſſer Orbits than the Earth, which bring them ſometimes between the Earth and the Sun; and hence their Tranſits.

Mars, *Jupiter* and *Saturn* are called ſuperior Planets, becauſe they are not only larger than the Earth, *Mars* excepted, but move alſo in larger Orbits.

Note, They are called Superior, with Reſpect to our Situation to the Sun, they moving in Orbits without us, or beyond our Orbit; whereas the other two are within us, or nearer to the Sun: For the Word Superior here, does not imply Magnitude, but Diſtance, Height, or uppermoſt.

The Earth has only one Moon attending it; *Jupiter* has 4, and *Saturn* has 5 Moons, which are alſo called *Satellites*. By the Motion of the Earth on its own Axis from Weſt to Eaſt, all the heavenly Bodies appear to move from Eaſt to Weſt.

All the Planets aforementioned are called primary ones; and the ſeveral Moons are called ſecondary Planets.

There is alſo another Sort called *Comets*, making very long and narrow Ellipſes round the Sun; being ſometimes ſo very near him, as to be within the Orbit of *Mercury*, and ſometimes ſo very remote as to be without the Orbit of *Saturn*.

The primary Planets are (ſome of them) to be ſeen every Night; but the *Comets* appear very ſeldom; and when ſeen, have generally long Tails of Light, always pointing directly from the Sun.

All the Planets, both primary and ſecondary, and alſo the *Comets* have no Light of their own, they being dark opake Bodies, but what they receive from the Sun; and therefore, when ſeen, only reflect the Light of the Sun; that is, exhibit a ſecond-hand Sun-ſhine.

Of the SUN.

This glorious Luminary is now, without all Diſpute, a ſolid Ball of Fire, as evidently appears by the Light and Heat, which we receive from it: And being placed in, or near the Center of our Syſtem of the Univerſe, gives Light and Heat to all other Orbs that move round about it.

Note, It is moſt certainly Solid, and without doubt very denſe too; alſo, compoſed of ſuch Matter, as is a proper and neceſſary *Pabulum* to ſupply the Fire upon the external Parts, which will be ſupplied from the inner Parts, as long as the great Creator ſhall conſerve this Solar Syſtem.

It cannot be placed upon the artificial celeſtial *Globe*, becauſe it is not fixed to any particular Point; its Place being ſometimes in one Part of the Ecliptic, and ſometimes in another, occaſioned by the Earth's Motion round it, which gives Room for the Expreſſion of the Sun's being in ſuch or ſuch a Sign; becauſe, when obſerved, it ſeems as if it were placed among the Stars belonging to ſuch a particular Sign.

Its Size, when compared with our *Globe* of the Earth, is monſtrous, being formerly found to be 600000 Times larger, and ſince the Computations of the laſt Tranſit of *Venus*, in the Year 1769, the Sun is found to be twice that Number, or 1200000 Times larger.

Of the MOON.

The Moon is an opake or dark Body, having no Light of its own, but what it receives from the Sun; and conſequently, when the Moon ſhines with all her Brightneſs on the Earth, it is but a reflected Light, or ſecond-hand Sun-ſhine. The Truth of this Aſſertion is evident, both from an Eclipſe of the Moon, and alſo of the Sun. In a total Eclipſe of the Moon, ſhe is ſeen indeed to have a faint Light, but it is no more than what the Shadow of the Earth admits from the circumambient Light of the Sun, the Earth being then between the Sun and Moon: But in a total Eclipſe of the Sun (which is occaſioned by the Moon's paſſing between the Sun and the Earth, and for that Time totally depriving us of his Light) eſpecially in a central one, at the Place of Obſervation, that Part of the Moon, which is next the Earth is quite Dark; and from hence it appears, that the Light of the Moon is not Native, and therefore can be only borrowed.

The Moon has a threefold Rotation or Revolution.

1. A Central one upon her own Axis, once in 27 *d.* 7 *h.* 43 *m.* from Weſt to Eaſt.

2. A circular one about the Earth, from Weſt to Eaſt alſo, which is performed in the ſame Time, and from thence called a Periodical Month, or Revolution.

3. An irregular, or mixt circular one about the Sun, from Weſt to Eaſt, at the ſame Time, that it is carried about the Earth; and this occaſions the Moon to be ſometimes within the Earth's Orbit, and ſometimes without it, making a ſerpentine Line, croſſing and recroſſing the Earth's Orbit, as in the Scheme or Diagram, *Plate* II. *Fig.* 2. which is the Reaſon of the New and Full Moons: For, when the Moon is within the Earth's Orbit, and between the Earth and the Sun, it is then the Time of Conjunction with the Sun, which is the Time of New Moon; and then it is that the enlightened Part of the Moon, or Time of Day there, is turned from the Earth, and the dark Part or Night is turned towards it. On the Contrary, when the Moon is without the Earth's Orbit, ſo as to have the Earth between her and the Sun, it is then the Time of the Moon's oppoſition to the Sun, or the Time of Full Moon; and then it is, that the enlightened Part of the Moon, or Time of the Day there, which before was Night, is turned towards the Earth, and the oppoſite Side is Night. When the Moon is in her Quadratures, we ſee but half of her enlightened Part, and then ſhe is in or near the Earth's Orbit.

From one Conjunction to another (and not from one Full Moon to another) is 29 *d.* 12 *h.* 44 *m.* which is called a Synodical Month or Revolution, from their meeting together in or near a ſtraight Line, the Moon being in the Middle.

Note 1. Tho' the Moon, in her Paſſage round the Earth and Sun together, forms an irregular Curve-line, from her being ſometimes within the Earth's Orbit, and ſometimes out of it, and in the Diagram terminates where ſhe began, it is only for the Figure's ſake, that ſhe does ſo: For in reality, ſhe does not end where ſhe began, but is continually making new Forms, tho' in the like regular Manner, always falling ſhort of the Place where ſhe began, till by a long Series of Years ſhe may fall into the ſame Curve-line again, where ſhe began firſt of all.

2. In the ſaid Diagram, at every New Moon, it ſeems as if the Moon's Paſſage was convex to the Sun, nor could it be made to appear otherwiſe in ſo ſmall a Figure: But Mr. *James Ferguſon*, F. R. S. in the Year 1745, has made it appear, by drawing a ſmall Portion of the Earth's Orbit, on a long Copper-plate, and thereon exhibited the Motion of the Moon, for a whole Lunation together; *i. e.* from one New Moon to another, that the Moon's Paſſage is always concave towards the Sun, ſhe forming a kind of Circle, tho' not a complete one in that Paſſage.

3. *Europe* is, by far, the ſmalleſt Quarter of the World, and alſo, by much the moſt Peopled; and as it is always Northward of the Meridian Sun; it is for this Reaſon, that the Eaſt is to the left, the South in the Front, &c. as in the ſaid Figure or Diagram.

A further Explanation of the MOON's Paſſage. See *Plate* II. *Fig.* 3.

Note 1. *a*, repreſents the Earth; and *b* the Moon.

2. At A, they are equidiſtant from the Sun, or firſt Quarter.

3. At B, the Moon, in her Path, is advanced to *b*, and make a full Moon, and is in Oppoſition; the Earth, in her Orbit being at *a*, and is directly between the two Luminaries.

4. At C, the Moon hath advanced, in her Path, to *b*, is, again, equidiſtant, with the Earth, from the Sun; is to the Eaſtward; and in her ſecond Quarter.

5. From hence, the Moon (as appears by the Lunar Arc) approaches nearer to the Sun, until the New Moon, when ſhe is neareſt; from whence ſhe will recede, until the Arcs interſect, as at the firſt Quarter.

6. Hence, it muſt evidently appear, from the Nature of the Arcs, even to the Senſes, that the Path of the Moon is conſtantly concave to an Eye placed in the Sun.
7. The ſtraight Line *a a* only ſerves to connect, and make more apparent, the firſt and ſecond Quarters of the Moon.

The ſame Part or Face of the Moon is always towards the Earth, without ever deviating from it.

As for the Lunar Days, we muſt not judge of them, as of our own; becauſe from Obſervation, the Moon takes a much longer Time to turn upon her Axis once round than the Earth does: For as the Moon has a Rotation on her own Axis once in 27 *d.* 7 *h.* 43 *m.* of our Time as aforeſaid, it is evident, that all that Time muſt conſtitute her natural Day, including Light and Darkneſs, as our natural Day conſiſts of 24 Hours. In Appearance to us indeed, the Moon's real Day ſeems to be nearly 15 of our Days, and her Night the ſame, from her Weſtern Limb (at the Time of New Moon) beginning to be enlightened, and ſo continuing till the full Moon, at which Time the ſame Weſtern Limb will then begin to be darkened (her night then coming on in that Part) and ſo continue for near 15 Days more, when her Weſtern Limb will begin to be enlightened again; but it is her Rotation on her own Axis, that determines the Length of her natural Day, that is, from any one Meridian or Noon of the Moon's Day to the Meridian or Noon of her next Day.

Of the EARTH.

What has been ſaid of the Moon, with regard to her Light, may with equal Truth be ſaid of the Earth: For the Light of the Earth is but borrowed, and ſerves as a Moon to that Body, which we call our Moon.

When the Moon is at the Full with us, the Earth is a New Moon to the Inhabitants there; and when it is New Moon with us, 'tis then the Earth ſhines with great Luſtre there, and becomes a reſplendent Full Moon.— If both Bodies reflect Light in Proportion to their Magnitudes, then the Earth will repay the Moon with fifteen Times more Light than it receives; for the Earth appears to the Lunar Inhabitants fifteen Times bigger —— Thus the Earth and Moon reflect the Sun's Light alternately on, and become Moon's to each other; continually waxing and waining; and when in their Quadratures, are at one and the ſame Time half enlightened to each other, each ſeeing the other with the Sun above the Horizon, but with theſe Differences;

Firſt, that our firſt Quarter is their laſt, and then we ſee the Moon to the Eaſt, and the Sun to the Weſt in the Afternoon; while at the ſame Time, they ſee our Earth to the Eaſt, and the Sun to the Weſt in the Morning of their Day.

Secondly, That our laſt Quarter is their firſt; and then we ſee the Moon to the Weſt, and the Sun to the Eaſt in the Morning, while, at the ſame Time, they ſee our Earth to the Weſt, and the Sun to the Eaſt in the Afternoon of their Day.

The Earth has two Sorts of Rotations or Revolutions: The firſt is a central one upon its own Axis, once in 24 Hours, which conſtitutes our natural Day; *viz.* from Noon to Noon: And the ſecond is a circular one round the Sun, which it performs in 365 *d.* 5 *h.* 49 *m.* 55 *ſec.* making our Year.

Note, The reſt of the Planets, both primary and ſecondary, having been mentioned before, in the Account of the *Copernican* Syſtem, prevents my ſaying any thing more of them here; only far, very far, beyond the Orbit of the moſt diſtant of them, which is *Saturn*, is that ſpacious, and moſt ſurprizing and delightful Scene of the fixed Stars.

Of the fixed STARS.

The fixed Stars are ſo called, becauſe they always ſhew themſelves in the ſame Situation, or nearneſs one to another.

They are generally accounted as ſo many Sun's, placed in the Centers of their own Syſtems, and ſhining with their own native Light, having other Bodies revolving round them, as the Moon, Earth, and the reſt of the Planets do round about the Sun in our Syſtem.

In Number, they are without doubt innumerable, becauſe very many of them, and by far the greater Part, have never reached human Sight, even with the beſt Teleſcopes; and thoſe that have been enumerated, are ſo extreamly diſtant, that no Art of Man hath yet been able to furniſh us with Inſtruments, whereby any tolerable Account of them may be given, otherwiſe than as they appear, ſome greater, and ſome leſs than others; which may be owing, in a great Meaſure to the Differences of their Diſtances from the Eye, as well as from the Differences of their Bulks.—From this Difference of their Bulks (in Appearance at leaſt) they are diſtinguiſhed according to their Magnitudes, *viz.* 6, or as ſome ſay 7; and hence, ſome Stars which appear the largeſt, are ſaid to be of the firſt Magnitude; others appearing ſomething leſs, of the ſecond Magnitude; others again of the third, fourth, and fifth Magnitude; and the ſmalleſt of all, of the ſixth or ſeventh Magnitude.

As to their riſing in the Eaſt, and ſetting in the Weſt, like the other Luminaries, it is owing to the Rotation of the Earth on its own Axis, from Weſt to Eaſt, once in 24 Hours; it being not unlikely, in the mean Time, but they may, like our Sun have their reſpective Motions, each one on its own Axis alſo.

For the better underſtanding and diſtinguiſhing them one from another, they have, long ſince, been reduced to certain Forms, Figures or Images, according to the Conceptions of the Ancients in the firſt Ages of the World, which have ever ſince been handed down to us under the ſame Repreſentations; and as later Times have produced ſome Improvements; ſo additional Conſtellations have been made, till at laſt they are juſt as we now obſerve them upon the celeſtial *Globe*. And as there are yet ſome unformed Stars: ſo in Time to come they alſo may be formed into other new Conſtellations.

The fixed STARS admit of four great Diviſions, *viz.*

1. The Northern Conſtellations.
2. The Southern Conſtellations.
3. The Conſtellations, or Signs of the Zodiac.
4. The *Via Lactea*; and therein of *Nebulous* Stars.

1. Of the NORTHERN CONSTELLATIONS.

The Northern Conſtellations are ſo called, becauſe they are ſituated round about the Celeſtial *Globe*, in the Northern *Hemiſphere*; *i. e.* between the North Pole and the *Zodiac*. They are 36 in Number; which, with the Number of Stars in each Conſtellation, and their Magnitudes, will ſtand as in the following Table, according to Mr. *Robertſon*.

Names of the Constellations.	Stars on the Globe.	Stars by the Teleſc.	Magnitudes.					
			I	II	III	IV	V	VI
Urſa Minor; little Bear - - - - -	10	12	0	2	1	4	3	2
Urſa Major; great Bear, or Charles's Wain - - - - - - - - - -	57	105	0	5	5	16	30	49
Draco; the Dragon - - - - - -	29	49	0	1	7	8	10	23
Cepheus - - - - - - - - - - - -	38	40	0	0	3	7	10	20
Canes Venatici; the Greyhounds, *viz.* Aſterion and Chara - - - - -	18	24	0	0	0	1	7	16
Boötes; the Bear-keeper - - - - -	38	53	1	0	7	10	12	23
Mons Mænalus; the Mountain Mænalus - - - - - - - - - -	7	11	0	0	0	1	0	10
Coma Berenice; Barenice's Hair - -	15	24	0	0	0	6	8	10
Cor Caroli; Charles's Heart - - - -	1	3	0	1	0	0	0	2
Corona Cnoſſia; Ariadne's, or the Northern Crown - - - - - - -	8	11	0	1	0	6	3	1
Hercules Engonaſis, becauſe he is kneeling - - - - - - - -	44	92	0	0	12	12	28	40
Cerberus; the three-headed Dog - -	5	9	0	0	0	3	1	5
Lyra; the Harp - - - - - - - -	15	24	1	0	3	2	8	10
Cygnus; the Swan, ſometimes called Olor - - - - - - - - - -	37	73	0	1	5	15	20	32
Vulpecula; the little Fox - - - - -	20	29	0	0	0	6	11	12
Anſer; the Gooſe - - - - - - -	3	10	0	0	0	0	2	8
Lacerta; the Lizard - - - - - - -	10	12	0	0	0	3	4	5
Caſſiopeia - - - - - - - - - - -	32	52	0	0	5	7	7	33
Camelopardalus, Camel-panther, or Camel-leopard - - - - - - -	30	23	0	0	0	5	7	11
Serpens; the Serpent of Ophiucus - -	13	50	0	1	7	6	5	31
Serpentarius, Eſculapius, or Orphiucus	29	67	0	1	6	12	17	31
Sobieſki's Shield - - - - - - -	6	8	0	0	0	2	3	3
Aquila; the Eagle - - - - - - - -	20	29	1	0	5	1	4	18
Antinous - - - - - - - - - - -	18	34	0	0	5	2	7	20
Delphinus; the Dolphin - - - - -	11	18	0	0	6	0	2	10
Equulus; the little Horſe, or Colt - -	4	12	0	0	0	4	1	7
Sagitta; the Arrow - - - - - - -	5	13	0	0	0	4	1	8
Andromeda - - - - - - - - - -	46	66	0	3	2	10	16	35
Perſeus, with Meduſa's Head - - - -	41	67	1	1	5	10	14	36
Pegaſus; the winged or flying Horſe -	30	81	0	3	4	9	11	54

Names of the Constellations.	Stars on the Globe.	Stars by the Teleſc.	Magnitudes I	II	III	IV	V	VI
Auriga; the Charioteer or Eriethonius, which contains two others, *viz.* Capra or Hircus, the Goat, and Hædi, or the Kids - - - - - -	32	46	1	1	1	9	9	25
Lynx; the Tyger - - - - - - - -	16	55	0	0	1	8	21	25
Leo minor; the little Lyon - - -	17	20	0	0	1	6	5	8
Triangulum majus; the great Triangle	5	10	0	0	0	3	1	6
Triangulum minus; the little Triangle	3	5	0	0	0	0	0	5
Muſca; the Fly - - - - - - - - -	4	6	0	0	1	2	2	1

2. Of the SOUTHERN CONSTELLATIONS.

The Southern Conſtellations are ſo called, becauſe they are ſituated round about the Celeſtial *Globe*, in the Southern *Hemiſphere*; *i. e.* between the South Pole and the *Zodiac*. They are 35 in Number, which with the Number of Stars in each Conſtellation, and their Magnitudes will ſtand as in the following Table.

Names of the Constellations.	Stars on the Globe.	Stars by the Teleſc.	Magnitudes. I	II	III	IV	V	VI
Cetus; the Whale - - - - - - -	38	80	1	2	8	13	10	47
Eridanus; the River Po - - - - -	39	72	1	0	10	24	19	28
Phenix - - - - - - - - - - - - -	13	13	0	1	5	5	0	2
Anſer Americanus; American Gooſe, (not on *Price's Globes*) - - - -		9	0	0	4	2	3	0
Orion - - - - - - - - - - - - -	60	93	2	4	3	19	15	50
Monoceros, or the Unicorn - - -	16	32	0	0	1	10	10	11
Canis minor, or Caniculus; the little Dog - - - - - - - - - -	12	14	1	0	1	0	2	10
Hydra; the Serpent - - - - - -	33	53	0	1	3	14	13	22
Sextans Uraniæ; Urania's Sextant - -	5	4	0	0	0	0	0	4
Crater; the Cup - - - - - - -	9	11	0	0	0	8	2	1
Cornix, or Corvus; the Crow - - -	8	8	0	0	2	2	2	2
Centaurus; the Centaur - - - -	28	36	2	6	6	14	8	0
Lupus; the Wolf - - - - - - -	24	36	0	0	3	6	18	9
Altare, or Ara; the Altar - - - -	7	9	0	0	1	6	1	1
Triangulum Auſtrale; the Southern Triangle - - - - - - - - -	5	5	0	1	2	0	2	0
Pavo; the Peacock - - - - - - -	13	14	0	1	3	5	4	1
Corona Auſtralis; the Southern Crown or Ixion's Wheel - - - - - -	13	12	0	0	0	1	3	8
Grus; the Crane - - - - - - - -	13	14	0	2	1	2	9	0
Piſcis Notius, or Auſtralis; the Southern Fiſh - - - - - - - - -	11	15	1	0	2	9	2	1

NAMES of the CONSTELLATIONS.	Stars on the Globe.	Stars by the Teleſc.	MAGNITUDES.					
			I	II	III	IV	V	VI
Lepus ; the Hare	12	25	0	0	4	9	4	8
Columba Noë or Noachi ; Noah's Dove	10	10	0	2	0	1	6	1
Robur carolinum ; the Royal Oak	10	13	0	1	2	6	4	0
Argo Navis ; the Ship Argo	45	48	1	6	11	13	14	3
Canis major ; the great Dog	18	29	1	5	1	4	10	8
Apis ; the Bees } not on *Price's*		4	0	0	0	2	2	0
Hirundo ; the Swallow } *Globes.*		11	0	0	0	4	3	4
Indus ; the Indian	13	12	0	0	0	4	6	2
Chamelion	10	10	0	0	0	0	9	1
Piſcis Volans ; the flying Fiſh	5	7	0	0	0	0	6	1
Xiphias, or Dorado ; the Sword Fiſh	4	7	0	0	2	2	1	2
Apus ; the Bird of Paradiſe	9	12	0	0	0	0	12	0
Muſca ; the Indian Fly	4	4	0	0	0	0	4	0
Toucan ; the Indian Fowl	9	8	0	0	4	3	1	
Hydrus ; the Southern Serpent	11	14	0	0	1	3	10	0
Croſiers ; the Croſs	4	4	0	2	2	0	0	0

3. Of the CONSTELLATIONS, or SIGNS of the ZODIAC.

The Signs of the Zodiac are in Number 12 ; and are divided into two Parts ; *viz.* ſix Northern Signs, and ſix Southern Signs. When the Sun has North Declination, he moves along the Northern Signs, and conſequently makes Summer to all thoſe Inhabitants in the Northern *Hemiſphere*, and Winter to all thoſe in the Southern *Hemiſphere* ; and when the Sun has South Declination, he moves along the Southern Signs, and conſequently makes Summer to all thoſe Inhabitants in the Southern *Hemiſphere*, and Winter to all thoſe in the Northern *Hemiſphere*.

In the Middle of the Zodiac is the *Via Solis*, or Sun's Way, called the Ecliptic, which makes two Angles with the Equinoctial, in the Points of ♈ and ♎ of 23° 29′, commonly called 23° 30′.

The Zodiac is 18° 30′ broad ; that is, 9° 15′ on each Side of the Ecliptic. In this *Plane* or *Zone*, all the Planets are found to move ; and thoſe, as the Comets and Stars, take their ſeveral Latitudes from the Ecliptic, in like Manner, as Places on the Terreſtrial *Globe* do from the Equator. The Sun has no Latitude, becauſe it is never out of the Ecliptic.

1. NORTHERN SIGNS.

NAMES of the CONSTELLATIONS.	Stars on the Globe.	Stars by the Teleſc.	MAGNITUDES.					
			I	II	III	IV	V	VI
Aries ; the Ram	19	46	0	1	1	3	5	36
Taurus ; the Bull, including the Pleiades, or 7 Stars	41	109	1	1	3	9	24	71
Gemini ; the Twins	29	94	1	2	4	8	13	66
Cancer ; the Crab	22	75	0	0	0	6	8	61
Leo ; the Lion	44	91	2	2	6	13	11	57
Virgo ; the Virgin	34	93	1	0	5	11	24	52

2. SOUTHERN SIGNS.

NAMES of the CONSTELLATIONS.	Stars on the Globe.	Stars by the Teleſc.	MAGNITUDES.					
			I	II	III	IV	V	VI
Libra; the Balance - - - - - -	13	33	0	2	1	8	3	19
Scorpio; the Scorpion - - - - - -	28	44	1	3	6	14	5	15
Sagittarius; the Archer - - - -	21	48	0	1	5	9	11	22
Capricornus; the Goat - - - - -	19	58	0	0	2	5	9	42
Aquarius; the Water-bearer and Water	37	93	0	0	4	7	28	54
Piſces; the Fiſhes, including the Linea Auſtralis and Borealis - - - -	37	110	0	0	1	7	28	74

Note 1. The Stars in each Conſtellation, diſcoverable by the bare Eye, are by ſome ſaid to be more, by others leſs: However, in the firſt Column of the Account aforegoing, I have only given thoſe which are upon the artificial Globe; eſpecially as I met with ſome, ſo extravagant as to give a larger Number in ſome Conſtellations, by the bare Eye, than that accurate obſerver Dr. *Flamſteed* could do by his Teleſcope.

2. There are five Conſtellations on the Globe; *viz. Camelopardalus*, *Sextans Uraniæ*, *Corona Auſtralis*, *Indus*, and *Toucan*, that have more Stars in each of them, than appear by the Teleſcope. How that happened, I am not able to judge, unleſs ſome were taken upon Truſt: However, as I found them ſo upon the Globe, I choſe to make this Obſervation, by Way of *Note*, rather than wholly paſs by the ſame, that it might not appear to be any miſtake of mine.

Of the VIA LACTEA.

The *Via Lactea*, milky Way, or Galaxy, is ſo termed from its whiteneſs or particular Light: and is occaſioned by a prodigious Number of Stars, that ſeemingly are very cloſe together, and produce that luminated Circle quite round the Heavens. Theſe Stars are not Viſible without an Inſtrument; but, by a good Teleſcope, and a good Eye are diſcoverable enough, and appear an incredible Number.

The *Via Lactea* is diſtinguiſhed on the artificial celeſtial Globe, by an irregular Cingulum, or Girdle of a bluiſh Colour. If, you begin at *Auriga*, it paſſes on towards the South, thro' the Head of *Monoceros*, leaving *Orion* and *Canis Major* to the Weſtward; then it paſſes thro' the Rigging of *Argo Navis*, *Robur Carolinum* and *Crux*; from thence it paſſes along by *Centaurus* and *Lepus*, and takes in the Tail of *Scorpio*, the Foot of *Serpentarius*, and Part of the Bow and Arrow of *Sagittarius*; from thence it paſſes on between *Antinous* and *Serpentarius*, including *Scutum Sobieſki*, where it divides; one Part taking in *Aquila*, *Vulpecula*, and one Wing of *Cygnus*; the other beginning at *Serpentarius*, includes a ſmall Part of *Cerberus*, Part of the Tail and Wing of *Lyra*, and the Neck, Body and Tail of *Cygnus*, where they join again and become One, and paſſes between *Cepheus* and *Lacerta*, taking in *Caſſiopeia*, where it inclines towards the Equinoctial, and takes in *Perſeus*, and ſo meets again at *Auriga*, and finiſhes that great Circumference.

The *Nubes Magellanicæ duæ*, or two Clouds of *Magellan*, ſo called from their being over *Terra Magellanica*, are of the ſame Nature with the *Via Lactea*, but no Part thereof, being of too great a Diſtance from it. Of this Kind alſo, are the *Nebulous* Stars, as follow.

Of NEBULOUS STARS.

Theſe Stars afford a whitiſh Light, reſembling that of the *Via Lactea*, and *Nubes Magellanicæ*; and like them alſo, are nothing elſe, but an Aſſemblage of exceeding ſmall teleſcopic Stars, ſeeming placed ſo near each other, that their Lights meeting together, form to the Eye, that one particular Light, which we ſometimes behold, in a clear Night, without the Moon. Or they are like a Light ſhining thro' a Miſt or Fog (whence the Name *Nebulous*, from *Nebula* a ſmall white Cloud, Miſt or Fog) which cannot be ſeen diſtinctly, but only as the circumjacent Miſt itſelf is enlightened by it.

Nebulous Stars are of two Sorts; *viz.*

1. Some appearing with a whitiſh Light about them; ſuch as the Star in the Middle of *Orion's* Sword, which, beſides that Star, contains 11 other ſmall teleſcopic Stars: And 2. The *Pleides* in the Neck of ♉ are ſaid to be of that Kind.

PROBLEM I.

The Day of the Month being given, to find the Sun's Declination.

Given, *April 19th.*
Required, the Sun's Declination.

1. Find the Sun's Place in the Ecliptic for the given Day, and mark it on the Globe.
2. Bring it to the Meridian, and there it appears to be 11° 16′ North.

Again,

Given, *November 14th.*
Required, the Sun's Declination.
Anſwer 18° 20′ South.

PROBLEM II.

The Sun's Declination being given, to find the Day of the Month.

Note, It muſt firſt be determined, whether the Declination be North or South; and alſo, whether the Sun be on the Eaſtern or Weſtern Side of the Tropic of ♋ or ♑; becauſe the Declination will be the ſame on both Sides, whether North or South.

Given, the Sun's Declination 12° 16′ N. on the Weſtern Side of the Tropic of ♋, or in the ſecond Quarter of the Ecliptic.
Required, the Day of the Month.

1. Mark the Sun's Declination on the Meridian with Chalk.

2. Turn the Globe, till ſuch Part of the Ecliptic as is on the Weſtern Side of the Tropic of ♋ coincide with the ſaid Mark, which determins the Sun's Place to be 29° 7′ in ♈.

3. Look in the Calendar on the Horizon, or in an *Ephemeris*; and againſt the Sun's Place, you will find *April* 19*th*.

Again,

Given, the Sun's Declination 18° 20′ S. on the Weſtern Side of the Tropic of ♑, or in the fourth Quarter of the Ecliptic.
Required, the Day of the Month.
Anſwer, *November* 14*th*.

PROBLEM III.

The Day of the Month being given, to find the Sun's Right Aſcenſion.

Given, *September* 27*th*.
Required, the Sun's Right Aſcenſion for that Day.

1. Mark the Sun's Place in the Ecliptic on the Globe.
2. Bring the ſame to the Meridian, and fix the Globe.
3. Obſerve what Degree of the Equinoctial is cut by the Meridian, reckoning from the firſt Point of ♈, which is about 183° 30′, that being the Right Aſcenſion required.

Note 1. If any other Day be propoſed (as it may be neceſſary for ſome Learner's to have a Number of them) the Sun's Place, for the given Day, is readily obtained on the Horizon, or by *Parker's Ephemeris*.

2. When the Sun juſt enters the firſt Scruple of ♈ he is then in his greateſt and leaſt Right Aſcenſion at the ſame Inſtant; the ending of one Sign being the ſame Point with the Beginning of another: Hence, when the Sun's Right Aſcenſion is 360°, that being the greateſt, he is ſaid to have no Right Aſcenſion at all, that alſo being the very Point of the Beginning of his Right Aſcenſion.

3. The Latitude in this Problem is out of the Queſtion, becauſe, whatever the Right Aſcenſion is for any Day, it is the ſame in every Latitude, and the Meridian will cut the Equator in the ſame Degree, whether the Sphere be right, oblique, or parallel.

PROBLEM IV.

The Latitude of a Place, and Day of the Month being given, to find the Sun's oblique Aſcenſion and Deſcenſion.

Given, *London*, 51° 32′ North, *Sept*. 27*th*.
Required, the Sun's oblique Aſcenſion and Deſcenſion.

1. Rectify the Globe, for the given Latitude.
2. Mark the Sun's Place upon the Globe.
3. Bring it to touch the Eaſtern Side of the Horizon.
4. Obſerve what Degree of the Equator is cut by the Horizon; for that is the Sun's oblique Aſcenſion, *viz*. 186° 30′.
5. Bring the Sun's Place to touch the Weſtern Side of the Horizon.
6. Obſerve what Degree of the Equator is cut by the Horizon, for that is the Sun's oblique Deſcenſion, *viz*. 181°.

PROBLEM V.

The Latitude of a Place, and Day of the Month being given, to find the Sun's aſcenſional Difference, *i. e.* how much he riſes or ſets, before and after 6. By which means the Length of any Day may be found, if the Index were loſt.

Given, *London*, Lat. 51° 32′ N. *Sept.* 27*th*.
Required, the Sun's aſcenſional Difference.

1. Find the Sun's right and oblique Aſcenſion, by *Prob.* III and IV.
2. Subtract the leſs from the greater, which ſoever they be, and the Remainder is the aſcenſional Difference.

	°	′	
Oblique Aſcenſion - -	186	30	3
			60
Right Aſcenſion - - -	183	30	15) 180 (12′
Aſcenſional Difference -	3	0	

3. Divide the aſcenſional Difference by 15 (which are the Degrees of the Equator, that paſs the Meridian of any Place in an Hour) the Quotient is the *Anſwer* in Time, which the Sun riſes or ſets before or after 6, *viz.* 6 *h.* 12′; *i. e.* the Sun riſes 12 Minutes after 6, and ſets 12 Minutes before 6; hence 5 *h.* 48 *m.* which is the Time from Noon to Sun-ſet, doubled, gives 11 *h.* 36 *m.* = the Length of the Day.

Note, The Sun's Right Aſcenſion, exceeds his oblique Aſcenſion, from ♈ to ♎, which is the Summer-half Year, and then the Sun riſes before 6 and ſets after 6: But, from ♎ to ♈, which is the Winter-half-Year, the Sun's oblique Aſcenſion, exceeds his Right Aſcenſion, and then he riſes after 6, and ſets before 6.—Or thus;

When the Latitude and Declination, are of one Kind, *i. e.* both North or both South, the Days are longer than the Nights; therefore the Sun riſes before 6, and ſets after 6; but, if of different Kinds; *i. e.* one North and the other South, then the Sun riſes after 6, and ſets before 6; and then the Nights become longer than the Days.

PROBLEM VI.

The Latitude, and Day of the Month being given, to find the Sun's Amplitude.

Given, *London*, Lat. 51° 32′ N. *Sept.* 27*th*.
Required, the Sun's Amplitude.

1. Rectify the Globe for the given Latitude.
2. Mark the Sun's Place in the Ecliptic.
3. Bring it to the Eaſtern Side of the Horizon, which ſhews his riſing, and fix the Globe.
4. Obſerve how many Degrees, on the innermoſt Side of the Horizon, the Sun is from the Eaſt Point, which is his Amplitude at riſing, on the given Day; *viz.* 3° 30′ S. or E. by S. ¾ E. = E. ¼ S. neareſt.
5. Bring the Sun's Place to the Weſtern Side of the Horizon, which ſhews his ſetting, and fix the Globe.

6. Obſerve how many Degrees, on the innermoſt Side of the Horizon, the Sun is from the Weſt Point, which is his Amplitude at ſetting, on the given Day; *viz.* 3° 30′ S. or W. by S. ¾ W. = W. ¼ S. neareſt.

Note, Whatever the Sun's Amplitude is to the Northward or Southward of the Eaſt Point, at his riſing, 'tis the ſame, or very nearly ſo, to the Northward or Southward of the Weſt Point at his ſetting.

PROBLEM VII.

The Latitude, Day of the Month, and Hour of the Night being given, to find the Sun's Depreſſion below the Horizon.

Given, *London,* Lat. 51° 32′ N. *May 20th,* 11 *hrs.* P. M.
Required, the Sun's Depreſſion below the Horizon, at that Time.

1. Elevate the Pole to the given Latitude.
2. Mark the Sun's Place in the Ecliptic.
3. Bring it to the Meridian, and fix the Globe.
4. Put the Index at Noon.
5. Find the oppoſite Place in the Ecliptic, by turning the Globe, till the Index points to 12 at Night, and mark it.
6. Turn the Globe, till the Index points to the given Hour, and fix it.
7. Fix the Quadrant of Altitude in the Zenith.
8. Bring the Quadrant of Altitude to touch the ſaid oppoſite Point in the Ecliptic, then will the Quadrant ſhew how many Degrees that is above the Horizon, which is equal to the Sun's Depreſſion below the Horizon, at the given Hour; *viz.* 17°.

PROBLEM VIII.

The Latitude, Day of the Month, and Hour being given, to find the Sun's Azimuth.

Given, *London,* Lat. 51° 32′ N. *May 20th* and 9, A. M.
Required, the Sun's Azimuth.

1. Rectify the Globe for the given Latitude.
2. Fix the Quadrant of Altitude in the Zenith.
3. Find the Sun's Place in the Ecliptic.
4. Mark it, and bring it to the Meridian.
5. Bring the Index to Noon.
6. Turn the Globe about, till the Index points to the given Hour, and fix it.
7. Bring the Edge of the Quadrant to touch the Sun's Place.
8. Examine the innermoſt Circle of the Horizon, and the Diſtance between the South Point and the Quadrant, will ſhew the Azimuth to be S. 66° E. or S. E. by E. ¾ E. at the given Time.

Note, The Sun's Azimuth may be found at any Hour. If in the Morning, it muſt be an Arch of the Horizon intercepted between that Azimuth Circle, which paſſeth thro' the Center of the Sun, and the Meridian in the oriental or Eaſtern Hemiſphere; but, if, in the Afternoon, then in the occidental or Weſtern.

PROBLEM IX.

The Latitude, Day of the Month, and Sun's Azimuth being given, to find the Hour of the Day.

Given, *London*, Lat. 51° 32′ N. *May 20th*, Sun's Azimuth S. 63° E.
Required, the Hour of the Day.

1. Rectify the Globe for the given Latitude.
2. Find the Sun's Place in the Ecliptic.
3. Mark it, and bring it to the Meridian, and fix the Globe.
4. Bring the Index to Noon.
5. Fix the Quadrant of Altitude in the Zenith.
6. Bring the graduated Edge to the given Azimuth, and hold it there.
7. Move the Globe with the other Hand, till the Sun's Place touch the Edge of the Quadrant, and fix the Globe again.
8. Obſerve the Index, and you will find it point to 9¼ A. M. which is the Hour of the Day.

PROBLEM X.

Any particular Star being given, to find its right Aſcenſion.

Given, *Bellatrix*, the bright Star in *Orion*.
Required, its right Aſcenſion.

Note, The Day of the Month is out of the Queſtion in this Caſe, becauſe all the Stars come to the Meridian of any Place, 4 Minutes ſooner every 24 Hours, than in the preceding; which is the Reaſon why they incline to the Weſtward more and more every Day, till at laſt they diſappear at Night, and are with us by Day.

1. Bring the given Star to the Meridian, and fix the Globe.
2. Obſerve what Degree of the Equinoctial is cut by the ſaid Meridian, reckoning from the firſt Point of ♈, which is the right Aſcenſion = 77° ½.

Alſo, ° ′
Regel, in the left Foot of *Orion* = 75 30
Sirius, or the Dog Star - - - = 98 30, and,
Cor Leonis, the Lyon's Heart - = 148 30.

Note, As the right Aſcenſion (above) and Declination (hereunder) of the fixed Stars are conſtantly altering, it is impoſſible to be ſo exact (by the beſt Globes) in their Diſcovery, as by Aſtronomical and Spherical Calculations.

PROBLEM XI.

Any particular Star being given, to find its Declination.

Given, *Deneb*, at the Root of the Lion's Tail.
Required, its Declination.

1. Bring *Deneb* to the Meridian, and fix the Globe.
2. Obſerve its Diſtance from the Equinoctial, *viz*. 17° 30′ N. = its Declination. Alſo,

° ′
Vendemiatrix, in *Virgo* = 13 30 N.
Spica, ditto - - - = 9 30 S.
Arcturus, in *Boötes* - = 21 7 N.

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PROBLEM XII.

Any particular Star being given, to tell its Latitude and Longitude.

Given, *Alcair*, in *Aquila*, on the North-ſide of the Ecliptic.
Required, its Latitude and Longitude.

1. Elevate the North Pole to 66° ½.

2. Bring the ſolſticial Colure to the Meridian, ſo that ♋ may be N. and ♑ S. and fix the Globe: then will the Ecliptic coincide with the Horizon.

3. Fix the Quadrant of Altitude in the Zenith, which here, is over the Pole of the Ecliptic.

4. Lay it over the given Star; ſo will *Alcair* appear by the Quadrant to be in Lat. 30° N.

5. Obſerve, where the Quadrant cuts the Ecliptic, *viz.* in 27° 40′ in ♑ or 298° 00′ from ♈, which is its Longitude. Alſo,

Nova, or the new Star in *Cygnus*, has 57° 00′ N. Lat. and 21° in ♒ or 321° from ♈, Longitude.

The left Eye of *Caput Meduſæ*, has 22° 40′ N. Lat. and 22° 50′ in ♉ or 52° 50′ from ♈, Longitude.

PROBLEM XIII.

The Day of the Month, and right Aſcenſion of a Star being given, to find the Time, when that Star culminates, or comes to the Meridian.

1. The Star Eaſtward of the Sun.

Given, *May 27th*, and the right Aſcenſion of the Star, on *Caſtor's* Left-hand = 98°.
Required, the Time, when that Star culminates.

1. Bring the Sun's right Aſcenſion to the Meridian.
2. Put the Index to 12 at Noon.
3. Bring the Stars right Aſcenſion to the Meridian, and fix the Globe.
4. Obſerve the Index, and it will point at 2 *h.* ¼ P.M. which is the Time of the Star's Culminating.

ARITHMETICALLY.

Subtract the right Aſcenſion of the Sun, from the right Aſcenſion of the Star (adding if needful 360°) the Remainder is the Difference, or Arch of the Equinoctial, that has paſſed the Meridian, between Noon, and the Time of the Star's Culminating. Thus,

	°	′
Right Aſcenſion of the Star =	98	0
Sun =	63	54
15)	34	6 (2

4
60

15) 246 (16
6
60

15) 360 (24 *Facit* 2 *h.* 16 *m.* 24 *ſ.*

2. The Star Weſtward of the Sun.

Given, *May 27th*, and the right Aſcenſion of the Star on *Andromeda's* left Elbow = 7° 45′.

Required, that Star's culminating.

1. Bring the Sun's right Aſcenſion to the Meridian.
2. Set the Index to Noon.
3. Bring the Star's right Aſcenſion to the Meridian, and fix the Globe.
4. Obſerve the Index, which will point at 8 *h.* ¼ A. M. for the culminating.

ARITHMETICALLY.

	°	′	
Right Aſcenſion of the Star =	7	45	
Add - - - - - - -	360	0	
	367	45	
Right Aſcenſion of the Sun =	63	54	
15)	303	51 (20	
	3		
	60		
15)	231 (15		*h.* *m.* *ſ.*
	6		20 15 24
	60		12 0 0
15)	360 (24		*Facit* 8 15 24 A. M.

PROBLEM XIV.

The right Aſcenſion and Declination of any Star being given, to find that Star upon the celeſtial Globe.

Given, a certain Star, whoſe right Aſcenſion is 84° 52′
Declination is 8° 0′ N.

Required, that Star.

1. Bring 84° 52′ on the Equinoctial to the Meridian, and fix the Globe.
2. Directly under 8° N. will appear the bright Star on *Orion's* right Shoulder, which is the Star required.

PROBLEM XV.

The Latitude of a Place being given, with any particular Star, to find the oblique Aſcenſion and Deſcenſion of that Star at that Place.

Given, *London*, Lat. 51° 32′ N. and *Cor Hydræ*.

Required, the oblique Aſcenſion and Deſcenſion of that Star.

1. Rectify the Globe for the given Latitude.
2. Bring the given Star to the Eaſtern Verge of the Horizon, and fix the Globe.
3. Obſerve what Part of the Equinoctial is cut by the Horizon, *viz.* 147°, which is its oblique Aſcenſion.
4. Bring the given Star to the Weſtern Verge of the Horizon, and fix the Globe again.
5. Obſerve what Part of the Equinoctial is cut by the Horizon, *viz.* 130°, which is the oblique Deſcenſion.

PROBLEM XVI.

The Latitude of a Place, Day of the Month, and any particular Star being given, to find the Time of that Star's riſing and ſetting, together with the Point of the Compaſs it riſes and ſets on, and its Duration above the Horizon.

Given, *London*, Lat. 51° 32′ N. *June 4th*, and *Vindemiartix* in *Virgo*. Required, the Time of that Star's riſing and ſetting; the Point of the Compaſs it riſes and ſets on; and its Duration above the Horizon.

1. Rectify the Globe for the given Latitude.
2. Find the Sun's Place, mark it on the Globe; bring it to the Meridian, and fix the Globe.
3. Put the Index to Noon.
4. Turn the Globe, till the given Star touches the Eaſtern Horizon, and fix it again.
5. By the Horizon, it appears, that the given Star riſes E. N. E. a little E.
6. By the Index, it appears, that it riſes at 52′ P. M.
7. Bring the given Star to the Weſtern Horizon, and fix the Globe again.
8. By the Horizon, it appears, that the Star ſets W. N. W.
9. By the Index, it appears, that the Star ſets at 3 *hrs.* A. M. the next Morning.
10. The Time between its riſing and ſetting, is the Time of its Duration above the Horizon, *viz.* 14 *hrs.* 8 *min.*

ARITHMETICALLY.

Subtract the Star's riſing from its ſetting (adding 12 Hours if need be) that Difference gives the Time of the Star's being above the Horizon.

	h.	*m.*	
Star's ſetting - -	3	0	A. M.
Add - - - - -	12	0	
	15	0	
Star's riſing - -	0	52	P. M.
	14	8	

PROBLEM XVII.

Two Stars being given, to find their Diſtance in Degrees and Minutes.

Note, This admits of four Variations.

1. Under the ſame Meridian.

Given, two Stars, one in the left Foot of *Chara*, the other near the Top of the right Wing of *Virgo*.
Required, their Diſtance.

1. Bring the given Star to the Meridian, and fix the Globe.
2. *Note*, their Declinations, which in this Caſe, are both North.
3. Take the Difference of their Declinations, which is the Diſtance required; *viz.*

	°	′	
That in *Chara* =	35	30	N.
Virgo =	17	30	N.
Difference =	18	0	= the Diſtance.

2. Under the ſame Parallel or Declination.

Given, one Star at the Top of the Ear of *Boötes*, and another in the lower Jaw of *Chara*, both in 41° 0′ North Declination.
Required, their Diſtance.

1. Bring both of them above the Horizon, and either of them to the Meridian, and fix the Globe.
2. Fix the Quadrant of Altitude over it.
3. Lay the Quadrant of Altitude to the other Star, and the Diſtance between them is 29° 15′: Or, fix (0°) of the Quadrant on one Star, and direct the ſame over the other; on the graduated Edge thereof is ſhewn the Diſtance between them.

3. In an oblique Situation.

Given, *Arcturus* in *Boötes*, and the Star in the right Shoulder of *Serpentarius*.
Required, their Diſtance.

Work as in the laſt Caſe, and their Diſtance will be = 51° 30′.

4. In the Equinoctial, or very near it.

Given, the Star next above the Belt of *Orion*, and another on the Bottom of the Neck of *Monoceros*.
Required, the Diſtance.

Reckon on the Equinoctial, the Degrees between them, and that is the Diſtance, *viz.* 25° 30′.

Note 1. None of the aforeſaid Diſtances are to be underſtood as real (for that no Man can tell) much leſs are they capable of being converted into Engliſh Miles, but only as they appear to us under their different Situations.

2. All the forgoing Varieties are reducible to one general Way of uſing the Quadrant of Altitude: but for the ſake of the Learner, I choſe theſe ſeveral Methods.

PROBLEM XVIII.

The Day of the Month being given, to find all thoſe Stars that will culminate, South, or be on the Meridian, both at Noon and Midnight.

Given, *July 19th*.
Required, all thoſe Stars, that will be on the Meridian at Noon and at Midnight.

1. Mark the Sun's Place on the Ecliptic.
2. Bring it to the Meridian, and fix the Globe.
3. Put the Index to Noon.
4. Obſerve what Stars lie under the Meridian, for thoſe are the Stars that South at Noon.
5. Turn the Globe, till the Index points at 12 at Night, and fix it again.
6. Obſerve what Stars lie under the Meridian, for thoſe are the Stars that South at Midnight.

PROBLEM XIX.

The Latitude of a Place, Day of the Month, and Altitude of any known Star being given, to find the Hour of the Night.

Given, *London*, Lat. 51° 32′ N. *Dec. 28th*, and *Deneb* in *Leo*, Altitude 40° in the oriental *Hemiſphere*.
Required, the Hour of the Night.

Note 1. It is neceſſary to know on which Side of the Meridian the Star is at the Time of Obſervation, becauſe it will have the ſame Altitude on both Sides of it.

2. The Altitude muſt be taken with a Quadrant, or ſome other Inſtrument proper for it.

3. As any Star may be taken at Pleaſure, it will be beſt to chuſe one that is not too near the Meridian: becauſe for about two Hours, *i. e.* an Hour before, and an Hour after any Star comes to the Meridian, the Altitude varies but very little, eſpecially if near the Zenith.

1. Rectify the Globe for the Latitude.
2. Put the Quadrant of Altitude in the Zenith.
3. Bring the Sun's Place to the Meridian, and fix the Globe.
4. Put the Index at Noon.
5. Move the Globe and the Quadrant together, till the Center of the Star meets the Quadrant in the given Degree of the Star's Altitude.
6. Obſerve the Index, which points to almoſt 2, A. M. the Hour required.

Note 1. If the ſame Star, and the ſame Altitude be ſuppoſed in the occidental Hemiſphere, or Weſt-ſide of the Meridian, the Operation on the Globe is the ſame, but, it will give a different Hour, *viz.* about 8 *h.* 6 *m.* A. M. of the ſame Day.

2. If the obſerved Star be upon the Meridian, at the Time of Obſervation, the Hour will be ſhewn, by bringing that Star to the Meridian of the Globe, and the Index will ſhew the Hour of the Night, *viz.* about 5 *h.* 7 *m.* A. M. of the ſame Morning.

PROBLEM XX.

The Latitude of a Place, Day of the Month, and Hour of the Night being given, to find the Azimuth of any particular Star at that Time.

Given, *London*, Lat. 51° 32′ N. *June 2d*, 9 P. M. and *Aſſingue* in *Lyra:*

Required, the Azimuth of that Star.

1. Rectify the Globe for the given Latitude.
2. Mark the Sun's Place in the Ecliptic, bring it to the Meridian, and fix the Globe.
3. Bring the Index to Noon.
4. Fix the Quadrant of Altitude in the Zenith.
5. Turn the Globe, till the Index points to the given Hour, and fix it again.
6. Look for *Lyra* on the Eaſtern-ſide of the Meridian, and therein for *Aſſingue*.
7. Lay the Quadrant over that Star, and hold it there.
8. Obſerve where it cuts the Horizon, *viz.* N. 74° E. = E. N. E. ½ E. nearly.

PROBLEM XXI.

The Latitude of a Place, Day of the Month, and Azimuth of any particular Star being given, to find thereby the Hour of the Night.

Given, *London*, Lat. 51° 32′ N. *June 2d*, and Azimuth of *Aſſingue* N. 73° E.

Required, the Hour of the Night.

1. Rectify the Globe for the given Latitude.
2. Mark the Sun's Place in the Ecliptic, bring it to the Meridian, and fix the Globe.
3. Bring the Index to Noon.
4. Fix the Quadrant of Altitude in the Zenith.
5. Lay the Quadrant to the given Degree of Azimuth, and hold it there.
6. Move the Globe, with the other Hand, till the Star touches the graduated Edge of the Quadrant, and fix it again.
7. Obſerve the Index, which points at 9 P. M. the Hour required.

PROBLEM XXII.

The Latitude of a Place being given, to find what Stars never ſet, and alſo what Stars never riſe in that Latitude.

Given, *London*, Lat. 51° 32′ N.

Required, all thoſe Stars, which never ſet, and which never riſe in that Latitude.

1. Rectify the Globe for the given Latitude.

2. Turn it quite round; and as you turn it, obſerve what Stars towards the North Pole don't go under the Horizon, which are thoſe that never ſet in the given Latitude; and are called Stars of perpetual Apparition.

3. Turn the Globe again quite round; and as you turn it, look under the Horizon, and obſerve what Stars, toward the South Pole don't appear above the Horizon, which are thoſe that never riſe in the given Latitude; and are called Stars of perpetual Occultation.

PROBLEM XXIII.

The Latitude, Day of the Month, and Hour of the Day being given, to ſet the Globe in ſuch Manner as to repreſent the Face of the Stars at that Time above the Horizon.

Given, *London*, Lat. 51° 32′ N. *June* 1*ſt*, at Noon.
Required, the Face of the Stars at that Time above the Horizon.

1. By a Compaſs, place the Globe due N. and S. allowing the Variation.

2. Rectify it for the given Latitude.

3. Mark the Sun's Place in the Ecliptic, bring it to the Meridian, and fix the Globe.

4. Put the Index to Noon. Thus you have the Heavens or Stars above the Horizon at that Time, tho' you cannot ſee them.

5. If you would ſee what Stars were above the Horizon any Time before Noon (ſuppoſe 9 A. M.) turn the Globe, till the Index points to 9, A. M. and you have all the Stars that were above the Horizon at that Time.

6. If you would ſee the Stars that will be above the Horizon, at 9 P.M. turn the Globe, till the Index points at the ſaid Hour, and you have all the Stars above the Horizon at that Time alſo.

7. If your Globe be placed abroad due N. and S. and the Weather clear without Clouds or Moon, you will find all the Stars to be in the ſame Poſition in the Heavens, as they are repreſented on the Globe: *i. e.* What Stars ſoever are juſt above the Eaſtern Horizon, thoſe Stars are then juſt riſing; what Stars are juſt above the Weſtern Horizon, thoſe Stars are juſt ſetting: and what Stars you obſerve to be juſt at the Meridian, thoſe Stars are then juſt culminating or ſouthing.

Note, By the Globe being thus placed, any particular Star obſerved in the Heavens may be found upon it; and on the contrary, any particular Star obſerved upon the Globe, may be found in the Firmament; and by this Means may all the Stars be known. For a Line, ſuppoſed to be drawn from the Center of the Globe, thro' any Star, and continued into the Heavens, it will point out the real Star therein: and if you take the Altitude of any Star in the Heavens, with a Quadrant, it will correſpond with the ſame on the Globe, meaſured with a Quadrant of Altitude.

PROBLEM XXIV.

The Latitude of a Place, and Day of the Month being given, to find all thoſe Stars that riſe and ſet Poetically, *i. e. Coſmically*, *Acronically*, and *Heliacally*.

1. COS-

1. *Coſmically.*

Note, Such Stars as riſe and ſet, at the Time of Sun-riſing, riſe and ſet *Coſmically*.

Given, *London*, Lat. 51° 32′ N. and *June* 1.

Required, all thoſe Stars, which riſe and ſet *Coſmically*.

1. Rectify the Globe for the given Latitude.
2. Mark the Sun's Place on the Ecliptic, bring it to the Eaſtern Horizon, and fix the Globe.
3. Obſerve what Stars are cut by the ſaid Horizon, for thoſe Stars riſe *Coſmically*.
4. Obſerve what Stars are cut by the Weſtern Horizon, for thoſe Stars ſet *Coſmically*.

2. *Acronically.*

Note, Such Stars as riſe and ſet, when the Sun ſets, riſe and ſet *Acronically*.

Given, as before.

Required, all thoſe Stars, that riſe and ſet *Acronically*.

1. Bring the Sun's Place to the Weſtern Horizon, and fix the Globe.
2. Obſerve what Stars are cut by the Eaſtern Horizon, for thoſe Stars riſe *Acronically*.
3. Obſerve what Stars are cut by the Weſtern Horizon, for thoſe Stars ſet *Acronically*.

3. *Heliacally.*

Note 1. Any Star is ſaid to riſe *Heliacally*, that is ſeen at the Eaſtern Horizon, a little before Sun-riſing.

2. Any Star is ſaid to ſet *Heliacally*, that is ſeen at the Weſtern Horizon, a little after Sun-ſetting.

3. The larger Stars will be diſcerned at a leſs Diſtance from the Sun than the ſmaller Ones; and therefore Stars of the firſt Magnitude may be ſeen ſetting within 13° of the Sun's Depreſſion below the Horizon: Stars of the ſecond Magnitude, within 14°: Stars of the third Magnitude, within 15°: Stars of the fourth Magnitude, within 16°: Stars of the fifth Magnitude, within 17°: and Stars of the ſixth Magnitude, within 18°. Hence, the Sun's Place being known, it will be eaſy to ſee what Stars will be at the forementioned Diſtances from him at riſing and ſetting, which will be the *Heliacal* riſing and ſetting.

4. Any greater Light will ſomewhat obſcure a leſſer. The moſt lucid and potent Rays of the Sun, will therefore render the faint Light of the Stars inviſible, when in the Courſe of the Sun, they approach him within thoſe Diſtances mentioned, according to their reſpective Magnitudes, and then they immerge into the Sun's Rays, and are ſaid to ſet *Heliacally*; and they thus continue conſtantly inviſible for ſome Time, and until the Sun is removed (or apparently ſo) to the ſame Diſtance from them, when they begin to re-appear, or emerge out of the Sun's Rays, which is called *Heliacal* riſing. And this riſing and ſetting is determined by the Stars Diſtances from the Sun, whether at the Sun's riſing, ſetting, or any other Time of the Day.

Given, as before.

Required, all thoſe Stars that riſe and ſet *Heliacally*.

1. Bring the Sun's Place to the Eaſtern-ſide of the Horizon (the Globe being rectified as before) and fix the Globe.
2. Fix the Quadrant of Altitude in the Zenith.

3. By turning the Quadrant Eaſtward, obſerve what Stars of the firſt Magnitude are 13° above the Horizon, for thoſe Stars riſe *Heliacally*; the like at 14° for thoſe of the ſecond Magnitude, *&c.*

4. Bring the Sun's Place to the Weſtern-ſide of the Horizon, and fix the Globe again.

5. By turning the Quadrant Weſtward, obſerve what Stars of the firſt Magnitude, are 13° above the Horizon, for thoſe Stars ſet *Heliacally*; the like at 14° for thoſe of the ſecond Magnitude, *&c.*

Note 1. A modern Writer on the Globes (Mr. *Fenning*) finds fault with the *Almanac* Writers, for beginning the *Dies caniculares*, or Dog-days on the 30*th* of *July*, from the *Heliacal* riſing of that famous Star called *Sirius*, a Star of the firſt Magnitude in *Canis major*, or great Dog; he miſtaking that Star for the *Coſmical* riſing of another called *Procyon*, a Star of the ſecond Magnitude in *Canicula*, or the little Dog. Now, as the Sun, on the 30*th* Day of *July* is then in 6° 54′ of ♌, if thoſe Degrees and Minutes be brought to the Eaſtern-ſide of the Horizon (the Pole being firſt elevated to the Latitude of the Place, *viz.* *London*) it will be found that, not *Sirius* (for *Sirius* will, at that Time, be near 9° below the Horizon) but *Procyon* will then riſe *Coſmically*; *i. e.* *Procyon* and the Sun will both riſe together, which is reckoned the firſt Day of the *Dies caniculares* (thoſe Days being ſo called from *Canicula* the little Dog) and that theſe *Dies caniculares* continue all the while that *Procyon* is hid in the Sun's Rays, which is till the 7*th* Day of *September*, at which Time, he being juſt emerged out of the Sun's Rays, becomes Viſible, and then riſes *Heliacally*, *i. e.* is ſeen to riſe a little before the Sun, and thus end the Dog-days.

2. The Heat of the Weather, common in thoſe Days, is by no means to be aſcribed to this Star, nor to the Sun's being in the Sign ♌ only, as ſome have thought; but to the Earth's being replete with the firey Rays of the Sun, which it had received during the foregoing Part of the Summer. Hence the Heat above the Earth, and the Heat within it, being reflected back again, muſt affect, more or leſs, every living Creature upon the Surface of it, where ſuch Heat is reflected: And if this is granted round about the Parallel of 51° 32′, it muſt be much more ſo in a Latitude more to the Southward; and moſt of all in the *torrid Zone*: And therefore, as the like Heat happens before the Dog-days, as well as in them, the *Dies caniculares* themſelves, are remarkable for nothing but the Dog-Star or *Procyon's* riſing, either with the Sun, or a little before it. Again;

Some aſcribe to the Dog-days the want of Health uſual at that Time in and about our own Latitude: The like Complaint was anciently made at *Rome*; but, *Horace*, in his 7th Epiſtle to *Mæcenas*) attributed the want of Health in that City, not ſo much to the Dog-days (tho' ſuch want of Health happened at that Time) but to the Fruits, particularly Figs, as *Ficus prima* ſeem to indicate, which, were eaten too liberally, they coming in at that Seaſon, and alſo to the exceſſive Heats, whereby Perſons became careleſs of themſelves; and this is the Caſe with ſuch as dwell quite round the Parallel of *London*, or more Southern Latitude. In the Dog-days, which make the latter Part of the Summer Quarter, the Seaſon affords plenty of ripe Fruits, of almoſt all Kinds, and theſe are fed upon in ſuch a plentiful Manner, that ſome (of the younger Sort eſpecially) ſcarce ever know when to leave off, which is the Reaſon, why ſo many alvine Fluxes, and other Diſorders prevail; add to this, the Heat of the Weather, firſt, immediately from the Sun, and ſecondly, reflected from the Earth as beforementioned, both which, contribute very largely, to make up that ſickly Seaſon here ſpoken of, and not at all the Dog-days merely as ſuch.

3. The Beginning and Ending of the Dog-days are not the ſame in every Latitude, they Beginning and Ending ſooner in a ſmall Latitude than in a large one, as is evident from depreſſing the Pole to a ſmall Latitude, when it will appear that the Sun muſt be in a Place in the Ecliptie, prior to that of a larger Latitude, to riſe *Coſmically* with *Procyon*, and in the higheſt Latitudes, where the Sun either ſets not, or riſes not for many Days together, and where *Procyon* never ſets, or, in high Southern Latitudes, where he never riſes, they have no Dog-days at all.

4. *Canicula, Sirius* and *Procyon*, were formerly one and the ſame Star in the Conſtellation, called *Canis Major*: The *Latins* called it *Canicula*, or little Dog; the *Greeks* Σείριος from Drought, becauſe, about that Time, the Fountains and Brooks were dried up, thro' exceſſive Heat; and Pliny and Galen *Procyon* from going before; that Star being always the firſt of that Magnitude, that appears in that Conſtellation.
5. To thoſe who lived in the Lat. of 30° N. as the antient *Egyptians*, and in a little higher Latitude, as the ancient *Grecians*, *Sirius*, when in the Meridians of thoſe Places, was, at the higheſt about 42° above the Horizon; whereas to the Inhabitants of the Lat. of 51° 32′ N. he is but 21° above the Horizon at higheſt: and in a Latitude ſuperior to that, he is ſtill lower.
6. *Canicula* to which *Procyon* belongs, as it is now underſtood, is a Conſtellation very different and diſtant from that called *Canis major* to which *Sirius* in the ancient *Canicula* belongs.
7. Hence it appears, that the Dog-days of the Moderns, and the Dogs-days of the Ancients are not the ſame, they being derived from different Conſtellations.
8. The *Dies caniculares* or Dog-days of the Moderns, begin with *Procyon*'s riſing *Coſmically* with the Sun; very likely in Imitation of the *Dies caniculares* of the Ancients, who began theirs with *Sirius*'s riſing *Heliacally*, making no Account of his riſing *Coſmically*, becauſe he could not then be ſeen (the *Canicula* of the Moderns being at that Time diſregarded) while *Sirius*, tho' a Star of the firſt Magnitude, is ſo remote in the Latitude of *London*, or higher, as not to be worth our taking Notice of in that Shape. Thus the Imputation of Error is eaſily taken from the Shoulders of our preſent *Almanac* Writers, and laid upon the Back of that Gentleman, who finds fault with them, he being in reality the only faulty Perſon.

PROBLEM XXV.

The Latitude of a Place, Day of the Month, and Moon's Place in the Ecliptic being given, to find her riſing, ſouthing, and ſetting.

Given, *London*, Lat. 51° 32′ N. *June* 1. and Moon's Place 17° 4′ in ♒.

Required, her riſing, ſouthing, and ſetting.

1. Rectify the Globe for the given Latitude.
2. Mark the Sun's Place, bring it to the Meridian, and fix the Globe.
3. Put the Index to Noon.
4. Mark the Moon's Place on the Ecliptic.
5. Bring it to the Eaſtern Horizon, and the Index will ſhew the Time of her riſing, *viz.* about 10′ paſt Midnight.
6. Bring it to the Meridian, and the Index will ſhew the Time of her Southing, *viz.* about 4 *h.* 38 *m.* A. M.
7. Bring it to the Weſtern Horizon, and the Index will ſhew the Time of her ſetting, *viz.* about 9 *h.* 22 *m.* A. M.

Note, This Problem is nearly alike with that of the Harveſt Moon. Prob. 67. p. 75.

PROBLEM XXVI.

The Latitude of a Place, Day of the Month, and any particular Planet being given, to find the Place of that Planet on the Globe, together with the Time of its riſing, ſouthing, and ſetting.

Given, *London*, Lat. 51° 32′ N. *Aug.* 1. ♄ 7° 25′ in ♉ and its Lat. 2° 29′ S.

Required, the Place of that Planet on the Globe, its riſing, ſouthing and ſetting.

1. Rectify the Globe for the Latitude of *London.*
2. Find the Sun's Place in the Ecliptic for the given Day.
3. Mark it, bring it to the Meridian, and fix the Globe.
4. Bring the Index to Noon.
5. Mark the Planet's Place on the Globe, according to its Latitude and Longitude.
6. Bring it to the Eaſtern-ſide of the Horizon, and fix the Globe.
7. Obſerve the Index, and you will find it riſe at almoſt 11 *h.* P. M,
8. Bring it to the Meridian, and fix the Globe again.
9. Obſerve the Index, and you will find it South, at 5 *h.* 37 *m.* A.M.
10. Bring it to the Weſtern Horizon, and fix the Globe again.
11. Obſerve the Index, and you will find it ſet at 12 *h.* 30 *m.* at Noon.

Note, The riſing, ſouthing and ſetting of a Comet may be thus obtained, when its Place is known.

Whereas mention has been made in ſeveral Pages foregoing, particularly, *p.* 53, 77, and 80, concerning an *Ephemeris*; I thought it would not be amiſs, in this Place, not only to ſhew what it is, but alſo to explain ſuch Paſſages therein, as are difficult to Learners; and alſo others, when they happen to meet with one, and reject it merely becauſe they are unable to underſtand it.

The Planets daily Motions Geocentric.

The Planets Latitudes and Place of ☽'s Node ☊ to every 6th Day.												☊	♎
	1	1N	55	1S	2	3N	56	0N	53	1N	40	15	23
	7	1	56	1	2	4	8	1	40	3	9	15	3
	13	1	58	1	2	4	18	1	27	3	18	14	43
	19	1	59	1	2	4	24	1	9	2	32	14	23
	25	2	1	1	1	4	25	0	51	1	29	14	3

M. D.	☉	♑	☽	♈	Lat.	☽	♄ ℞	♍	♃	♓	♂ ℞	♌	♀	♐	☿ ℞	♑	Sun's Decli. South.	
1	11	31	17	50	0S.	11	13	2	1	9	8	3	4	15	21	3	22	58
2	12	32	29	38	1	13	13	1	1	21	7	46	5	28	20	4	22	53
☉	13	33	11 ♉	29	2	12	13	0	1	33	7	28	6	41	18	57	22	47
4	14	34	23	28	3	6	12	58	1	45	7	10	7	54	17	43	22	40
5	15	35	5 ♊	28	3	52	12	57	1	57	6	51	9	7	16	24	22	33
6	16	37	18	3	4	28	12	56	2	9	6	32	10	20	15	2	22	20
7	17	38	0 ♋	46	4	51	12	54	2	21	6	12	11	34	13	42	22	18
8	18	39	13	46	5	0	12	52	2	34	5	51	12	47	12	27	22	10
9	19	40	27	3	4	56	12	50	2	46	5	30	14	0	11	17	22	1
☉	20	41	10 ♌	35	4	30	12	48	2	59	5	8	15	14	10	14	21	52
11	21	42	24	19	3	51	12	46	3	11	4	45	16	27	9	15	21	43
12	22	43	8 ♍	11	2	58	12	44	3	24	4	22	17	41	8	3	21	33
13	23	45	22	8	1	54	12	42	3	36	3	59	18	55	7	57	21	23
14	24	46	6 ♎	10	0	42	12	40	3	49	3	35	20	8	7	30	21	12
15	25	47	20	14	0N	32	12	37	4	2	3	11	21	22	7	12	21	1
16	26	48	4 ♏	20	1	45	12	35	4	15	2	47	22	35	7		20	49
☉	27	49	18	27	2	52	12	32	4	28	2	23	23	49	7	4	20	37
18	28	50	2 ♐	34	3	47	12	29	4	41	2	0	25	3	7D.	13	20	25
19	29	51	16	39	4	29	12	26	4	54	1	36	26	17	7	26	20	12
20	♒	52	0 ♑	40	4	54	12	23	5	7	1	12	27	31	7	48	19	59
21	1	53	14	31	5	2	12	20	5	20	0	48	28	45	8	17	19	46
22	2	54	28	9	4	52	12	17	5	33	0	24	29	58	8	52	19	32
23	3	55	11 ♒	30	4	26	12	14	5	47	0	1	1 ♑	12	9	32	19	18
☉	4	56	24	33	3	47	12	11	6	0	29 ♋	37	2	26	10	16	19	3
25	5	57	7 ♓	16	2	57	12	8	6	14	29	13	3	40	11	3	18	48
26	6	58	19	41	2	0	12	5	6	27	28	50	4	53	11	54	18	33
27	7	59	1 ♈	50	0	58	12	2	6	41	28	28	6	7	12	49	18	18
28	9	0	13	48	0S.	6	11	58	6	55	28	6	7	21	13	48	18	2
29	10	1	25	38	1	9	11	54	7	9	27	44	8	35	14	50	17	45
30	11	2	7 ♉	26	2	8	11	51	7	22	27	22	9	49	15	54	17	29
☉	12	3	19	18	3	3	11	47	7	36	27	1	11	3	17	0	17	13

The Heliocentric Motions.													JANUARY, 1773.		
Days	♄	♍	♃	♓	♂	♋	⊕	♋	♀	♎	☿	♊	Day-light B. and E	Sun riſes and ſets.	Clock too faſt.
1	7	42	9	48	22	23	11	31	8	29	19	3	5 59 7	8 9 4	4 22
7	7	51	10	21	25	7	17	38	18	10	25♋	53	5 56 7	8 5 4	7 4
13	8	8	10	53	27	51	23	45	27	49	28♌	9	5 52 7	7 59 5	9 30
19	8	20	11	25	0♌	33	29	51	7♏	26	24♍	52	5 46 7	7 51 5	11 28
25	8	33	11	38	3	15	5♌	57	17	2	17♎	9	5 39 7	7 42 5	13 7

M	H. Wat. Lon. B.				The Lunar Aſpects.						The Mutual Aſpects.
D.	Morn.		After.		☉	♄	♃	♂	♀	☿	
1	7	23	7	49						□ 3	☽ Apog.
2	8	25	8	42			✱ 3	□ 16			△ ☉ ♄
☉	9	12	9	42	△ 4	△ 4				△ 14	△ ♂ ☿
4	10	11	10	40			□ 18				
5	11	10	11	40		□ 13		✱ 2	☍ 8		☌ ☉ ☿
6			0	8							
7	0	36	1	3		✱ 22	△ 3			☍ 21	□ ♄ ♀
8	1	31	1	57	☍ 10						△ ♄ ☿
9	2	23	2	44				☌ 16			
☉	3	5	3	22					△ 8		
11	3	39	3	55			☍ 16				
12	4	11	4	31		☌ 8			□ 17	△ 1	
13	4	51	5	11	△ 3			✱ 19			
14	5	31	5	56						□ 2	
15	6	21	6	48	□ 10			□ 21	✱ 2		☽ Perig.
16	7	16	7	48		✱ 16	△ 0			✱ 6	
☉	8	21	8	57	✱ 18			△ 23			
18	9	32	10	9		□ 17	□ 3				
19	10	47	11	13					☌ 18		
20	11	49				△ 20	✱ 8			☌ 12	☍ ☉ ♂
21	0	29	1	0							
22	1	28	1	55	☌ 9			☍ 4			
23	2	21	2	47							
☉	3	4	3	21			☌ 22		✱ 16		
25	3	36	3	5[illegible]		☍ 10				✱ 8	
26	4	4	4	19				△ 18			
27	4	26	4	53	✱ 12				□ 10		✱ ♃ ♀
28	5	10	5	26						□ 0	
29	5	46	6	6				□ 5			☽ Apog.
30	6	29	6	52	□ 8	△ 10	✱ 0		△ 5	△ 20	
☉	7	17	7	43				✱ 16			△ ♄ ♉

A ſhort Explanation of the latter Part of PARKER's EPHEMERIS.

1. THE Place of a Planet, when it is viewed from the Earth, is called its *Geocentric* Place; as on the left hand Pages.

2. The Place of a Planet, when it is viewed from the Sun, is called its *Heliocentric* Place, as on the right hand Pages.

3. The *Geocentric* Places of the Sun, Moon, and Planets, are taken Notice of in every Day of every Month.

4. The *Heliocentric* Places only once in ſix Days.

Note, In the Uſe of the Globes, regard is had to the *Geocentric* Places; but in the Uſe of the Orrery, regard is had to the *Heliocentric* ones.

5. The ſmall Table, at the Top of the left hand Page, contains the Planets Latitudes, calculated to every ſixth Day; and are ſometimes N. or *North*, and ſometimes S. or *South*: And the Planets are noted at the Bottom of that Table, they ſerving for their reſpective Columns, both upwards and downwards.

6. At the End of this Table is a little Column, reſpecting the Moon's aſcending Node, marked thus ☊, which ſhews the Sign, and alſo the Degree and Minute of ſuch ☊ in that Sign.

7. The reſt of the Page, which contains the Planets Motions *Geocentric* is explained as follows, *viz.*

(1.) The firſt Column contains the Days of the Month, marked M. D.

(2.) The next contains the Sign, Degrees and Minutes, which the Sun is in for each Day.

(3.) The next contains the Sign, Degrees and Minutes, which the Moon is in for each Day.

(4.) The next contains the Moon's Latitude, which is ſometimes B. or *Borealis*, *Northern*; and ſometimes A. or *Auſtralis*, *Southern*.

(5.) The next five Columns, contain the Signs, Degrees and Minutes of the ſeveral Planets ♄ *Saturn*, ♃ *Jupiter*, ♂ *Mars*, ♀ *Venus*, and ☿ *Mercury*, which are ſometimes D. or *Direct*, moving from Weſt to Eaſt, and ſometimes ℞ or *Retrograde* moving from Eaſt to Weſt: And when any of them move ſo ſlow as to continue in the ſame Sign, for a good many Days together, ſuch Planet is ſaid to be *Stationary*, tho' it is never marked as ſuch.

(6.) The laſt Column, contains the Degrees and Minutes of the Sun's Declination, which is ſometimes N. or *North*, and ſometimes S. or *South*, according as it is North or South of the Equinoctial Line.

7. The right hand Page, contains as follows, *viz.*

(1.) The *Heliocentric* Motions of the Planets ♄ *Saturn*, ♃ *Jupiter*, ♂ *Mars*, ⊖ or ⊕ the *Earth*, ♀ *Venus*, and ☿ *Mercury*, in Signs, Degrees and Minutes, as viewed from the Sun, in Part of a ſmall Table at the Head of the Page. The other Part of the ſaid ſmall Table, contains (1) the Beginning and Ending of Day-light, where it is to be obſerved that the middlemoſt of the three Rows of Numbers is Minutes, thoſe on each Side are Hours, and ſignify that whenever Day-light begins (as on the firſt Day of *January*) at 59 Minutes after 5 in the Morning, it ends 59 Minutes before 7 at Night, or 1 Minute after 6. (2) The next contains the Riſing and Setting of the Sun, where it is to be obſerved, as before, that the middlemoſt of the three Rows of Numbers is Minutes, and thoſe on each Side are Hours, and ſignify that whenever the Sun riſes (as on the firſt Day of *January*) at 9 Minutes after 8 in the Morning, it ſets 9 Minutes before 4 in the Afternoon. (3) The next contains the true Account of Time, that a good Clock ought to go at, whether faſter or ſlower than the Sun; and ſignifies (as on the firſt Day of *January*) that a good Clock ſhould be 4 Minutes, 22 Seconds faſter than the Sun.

8. Below this ſmall Table, is another, but larger, and ſignifies as follows, *viz.*

(1.) The firſt Column contains all the Days of the Month in their natural Order.

(2.) The next contains the Time of High-Water at *London-Bridge* in the Morning.

(3.) The next contains the like in the Afternoon.

(4.) The next 6 Columns, contain the ſeveral Aſpects of the Sun and Planets, as they are Longitudinally diſtant from the Moon; and therefore are called Lunar Aſpects, which contain ſeveral Marks, as follow, *viz.*

When the Sun or any of the Planets are a third Part of the Ecliptic or 4 Signs, *i. e.* 120 Degrees diſtant from the Moon, this Mark △ called a Trine is uſed.

When they are but 3 Signs, or a fourth Part of the Ecliptic diſtant, *i. e.* 90 Degrees, they are ſaid to be Quartile, which is ſignified by this Mark □.

When they are but 2 Signs, *i. e.* 60 Degrees diſtant, they are ſaid to be Sextile, and known by this Mark ✱.

When any two Planets are in Conjunction, they are ſhew'd by this Mark ☌.

Note, Two celeſtial Bodies are ſaid to be in Conjunction, when both are upon the ſame Line of Longitude; tho' they may not be in the ſame Point of the Heavens; but ſeveral Degrees diſtant in Reſpect of Latitude.

When in Oppoſition they are diſtinguiſhed by this Mark ☍, and the Figure or Figures placed after any ſuch Mark, ſhew the Hour from Noon when ſuch Aſpect happened, or ſhall happen, on the Day againſt which that Number ſtands.

9. The next and laſt Column, contains the mutual Aſpects, or as they were formerly called (by the then Editor) Aſpects at the Earth; *i. e.* ſuch as are to be ſeen by the Inhabitants of the Earth: Theſe Aſpects being ſometimes △ Trine, ſometimes □ *Quartile*, ſometimes ✱ *Sextile*, ſometimes ☌ in *Conjunction*, and ſometimes ☍ in *Oppoſition*: Tho' no more Planets than 2 are obſerved at any Time to be ſo in the ſaid *Ephemeris*.

10. In the ſame Column of mutual Aſpects, the Moon's being in *Apogee* and *Perigee* are mentioned, which ſignify, that when the Moon is in *Apogee*, ſhe is then fartheſt from the Earth; and when in *Perigee*, ſhe is then neareſt to it.

11. There are alſo two other Words, *viz.* *Aphelion* and *Perihelion*, which tho' not mentioned in the *Ephemeris*, I think it improper to let them paſs

by unobſerved. That Point of the Earth's, or of any Planet's Orbit, wherein ſuch Planet is fartheſt off from the Sun is called its *Aphelion*, and the oppoſite Point, in which it is neareſt to the Sun is called its *Perihelion*.

Now in Order to make all this appear plain and eaſy to the Pupil, let any Day in the Month *January* be taken at Pleaſure, as *January* the *7th*, on the left hand Page; at the upper Part of it, it appears that ♄ was in 1° 56′ N. Lat. ♃ in 1° 2′ S. Lat. ♂ in 4° 8′ N. Lat. ♀ in 1° 40′ N. Lat. ☿ in 3° 9′ N. Lat. and the Moon's Node in 15° 3′ of ♎.

In the lower Part, for the ſame Day of *January*, it appears that the ☉ was in 17° 38′ of ♑ *Capricorn*; ☽ in 0° 46′ of ♋ *Cancer*; the Lat. of the ☽ was 4° 51′ S.; ♄ moved Retrograde 12° 54′ in ♍ *Vergo*; ♃ moved direct 2° 21′ in ♓ *Piſces*; ♂ moved Retrograde 6° 12′ in ♌ *Leo*; ♀ moved Direct 11° 34′ in ♐ *Sagittarius*; ☿ moved Retrograde 13° 42′ in ♑ *Capricorn*; and the Sun's Declination was 22° 18′ S. of the Equinoctial.

On the right hand Page, let the ſame *7th* Day be given, and then on the upper Part of the Page on the ſame Day it will appear, that, to an Eye in the Sun, ♄ was 7° 51′ in ♍ *Vergo*; ♃ was 10° 21′ in ♓ *Piſces*; ♂ was 25° 7′ in ♋ *Cancer*; ⊕ was 17° 38′ in ♋; ♀ was 18° 10′ in ♎ *Libra*; and ☿ was 25° 53′ in ♋ *Cancer*; Day-light began 56 Minutes after 5 in the Morning, and ended 56 Minutes before 7 at Night; the Sun aroſe 5 Minutes after 8 in the Morning, and ſat 5 Minutes before 4 in the Afternoon; and a good Clock was 7 Minutes, 4 Seconds, too faſt.

Again on the ſame *7th* Day, it was High Water, 36 Minutes after 12 in the Morning, and 3 Min. after 1 in the Afternoon; ♄ and the Moon were ✱ *Sextile*, or 60° diſtant, 22 Hours after Mid-day or Noon; that is 10 o'Clock on the next Day in the Morning; ♃ and the Moon were △ Trine, or 120° diſtant, at three o'Clock in the Afternoon; ☿ and the Moon were in Oppoſition 21 Hours after Mid-day, that is 9 o'Clock in the Morning of the next Day; and ♄ and ♀ were □ Quartile or 90° diſtant.

A new and complete

DESCRIPTION

Of the TERRESTRIAL and CELESTIAL

GLOBES,

With their ſeveral Uſes.

PART VIII.

Containing 12 Nautical *Problems*; or, various Methods of finding the Latitude at SEA, by the GLOBES.

I. By the SUN.

PROBLEM I.

THE Sun's Meridian Altitude and Declination being given, to find the Ship's Latitude.

Given, the Sun's Meridional Altitude, Southward of the Obſerver, 57° 31′ and Declination N. 19° 3′.

Required, the Latitude.

Note, The Declination is found in an *Ephemeris*, or Books of Navigation for any Day of the Month.

1. Mark the Degrees of Declination on the Meridian.

2. Slide the Meridian upwards or downwards, till that Mark is 57° 31′ above the Horizon on the Southern Side.

3. Then obſerve, on the other Side of the Horizon, how many Degrees the Pole is elevated, which is equal to the Latitude required, *viz.* 51° 32′ N. Or,

The Degrees of the Meridian, cut by the Horizon on the Southen-ſide, are equal to the Complement of the Latitude.

PROBLEM II.

The Sun's Declination and Amplitude being given, to find the Ship's Latitude.

Given, the Sun's Declination 13° W. and Amplitude 20° Northerly from the Eaſt.

Required, the Latitude.

1. Elevate the North Pole to the Complement of the Amplitude, *viz.* 70°.
2. Bring the firſt Point of ♈ to the Meridian, and fix the Globe.
3. Fix the Quadrant of Altitude in the Zenith.
4. Mark the Degrees of the Sun's Declination upon the Quadrant.
5. Move the Quadrant, till the Mark on it cuts the Equator, which will be in 48° 52′ the Latitude deſired, reckoned from ♈.

PROBLEM III.

The Sun's Altitude, at any Hour before or after Noon, his Azimuth and Place being given, to find the Ship's Latitude.

Given, the Sun's Altitude 20° 0′ A.M.
—— Azimuth 64° 20′ from the S. or S.E. by E. ¾ E. nearly.
—— Place — 25° 13′ ♍.
Required, the Latitude.

Note, The Sun's Place is found by an *Ephemeris*, or on the Horizon of the Globe, for the Day of the Month.

1. Find the Sun's Place in the Ecliptic, and mark it.
2. Elevate the North or South Pole (according to the Side of the Line the Ship is on, which here is ſuppoſed to be North) to the Sun's Altitude = 20°.
3. Fix the Quadrant of Altitude in the Zenith.
4. On the Horizon, reckon 64° 20′ from the South, and bring the Quadrant to that Point, where keep it.
5. Turn the Globe about, till the Sun's Place, and the Quadrant coincide, which will be in 51° 32′ the Latitude required.

PROBLEM IV.

The Sun's Declination, and Altitude due Eaſt or Weſt being given, to find the Ship's Latitude.

Given, Sun's Declination 17° 22′ N. Altitude 22° 25′ due E.
Required, the Latitude.

1. Elevate the North Pole to the Complement of the Sun's Altitude, *viz.* 67° 35′.
2. Fix the Quadrant of Altitude in the Zenith.
3. Bring the firſt Point of ♈ to the Meridian, and fix the Globe.
4. Reckon, on the Quadrant, the Sun's Declination upwards, and mark it.
5. Bring that Mark to the Equinoctial.
6. Obſerve, where it cuts the Equinoctial, *viz.* in 38° 28′ the Complement of the required Latitude, or 51° 32′ N.

PROBLEM V.

The Sun's Declination, and the Time, when he is due Eaſt or Weſt, being given, to find the Ship's Latitude.

Given, the Sun's Declination 17° 22′ N. and due Eaſt at 7*h.* A. M. Required, the Latitude of the Place.

Note, When the Declination is South in North Latitude, or North in South Latitude, the Sun is never due Eaſt or Weſt above the Horizon, during that Time.

1. Elevate the North Pole (becauſe the Latitude is ſuppoſed to be North, tho' the Degree is not known) to the Sun's Declination.

2. Fix the Quadrant of Altitude in the Zenith.

3. Reduce the Time from 6 o'Clock into Degrees, which is one Hour = 15°.

4. Reckon, thoſe Degrees upon the Horizon, from the Eaſt, Southward, becauſe the Obſervation is made in the Morning, and there make a Mark.

Note, If the Obſervation had been made in the Evening, then the Degrees ſhould have been reckoned from the Weſt, Southward.

5. Bring the Quadrant of Altitude to this Mark, and hold it there.

6. Obſerve what Degree of the Quadrant is cut by the Equinoctial, *viz.* 39° 30′, the Complement of the Latitude, or 50° 30′ from the Zenith.

Note, It is not material, what Part of the Equinoctial coincides with the Quadrant, becauſe, if the Globe be turned quite round, every Part of the Equinoctial will touch the Quadrant in the ſame Point.

PROBLEM VI.

The Sun's Amplitude and Aſcenſional Difference being given, to find the Ship's Latitude.

Given, the Sun's Amplitude 19° from the Eaſt, Southward; and Aſcenſional Difference 15°.

Required, the Latitude.

1. Elevate the North Pole to the Aſcenſional Difference, *viz.* 15°.

2. Fix the Quadrant of Altitude in the Zenith.

3. Bring the firſt Point of ♈ to the Meridian, and fix the Globe.

4. Mark the Complement of the given Amplitude upon the Quadrant.

5. Bring that Mark to the Equinoctial, which will cut it nearly in the ſame Degree, with that of the Sun's Declination, *viz.* about 12°; at the ſame Time the Quadrant will cut the Horizon in the Degree of the Pole's Elevation, *viz.* 51° 6′ from the Eaſt, which is the Latitude required.

II. By the STARS.

PROBLEM I.

The Meridian Altitude of a known Star being given, to find the Ship's Latitude.

Given, *Aldebaran,* in ♉ 52° 30′ its Meridian Altitude.

Required, the Latitude.

1. Bring *Aldebaran* to the Meridian, and fix the Globe.

2. Reckon the given Altitude towards the Southern-ſide of the Horizon from the given Star; and at the end of the 52° 30′ make a Mark on the Meridian.

3. Bring that Mark to the South-part of the Horizon.

4. Obſerve on the North-ſide, how many Degrees the North-pole is elevated, *viz.* 51° 32′, which is the Latitude required.

PROBLEM II.

Two Stars taken at Pleaſure, the one in the Meridian, the other riſing or ſetting, being given, to find the Ship's Latitude.

Given, one Star any where in the Meridian, *viz.* *Mencar*, in *Cetus*; and another, *viz.* *Cor Leonis*, juſt riſing.
Required, the Latitude.

1. Bring the Star, in the Meridian of the Heavens, to the Meridian of the Globe, and fix the Globe to the Meridian.

2. Move the Meridian upwards or downwards, till you ſee *Cor Leonis*, juſt riſing.

3. Obſerve how many Degrees the Pole is elevated, *viz.* 51° 32′, which is the Latitude required.

PROBLEM III.

The ſeveral Altitudes of two Stars, taken at Pleaſure, on the ſame Azimuth, or Point of the Compaſs, being given, to find the Ship's Latitude.

	°	′	
Given, *Procyon*, Altitude - - - - - -	32	30	S.E. ¼ E. or S.E. by E. nearly.
The Thigh of *Caſtor*, or left Knee of *Pollux*	49	30	

Required, the Latitude.

1. Bring the given Stars above the Horizon, in the oriental *Hemiſphere*, becauſe their Azimuth is in that Semicircle, or on that Side.

2. Move the Quadrant of Altitude on the Meridian, in ſuch Manner, that it may touch both the obſerved Stars, at their proper Degrees of Altitude, and fix it.

3. Fix the Globe to the Meridian, and keep the Quadrant in this Situation.

4. Move the Meridian in the Socket, and therewith the Globe, till 0 on the Quadrant coincide with, or touch the Horizon, in the S. E. by E. Point thereof.

5. Obſerve how much the Pole is elevated, *viz.* 51° 32′, which is the Latitude required.

PROBLEM IV.

The Declination and Azimuth of a Star being given, to find the Ship's Latitude.

	°	′	
Given, *Arcturus*, in *Boötes*, Declination	21	0	N.
- - - - - - - Azimuth	55	0	or N.E. by E. nearly.

Required, the Latitude.

1. Elevate the North Pole to the given Azimuth.
2. Fix the Quadrant of Altitude in the Zenith.
3. Mark the Star's Declination on it.

4. Bring the firſt Point of ♈ to the Meridian, and fix the Globe.

5. Turn the Quadrant of Altitude, till 21° marked on it coincide with the Equinoctial, which will be at 51° 32′ = to the Latitude required.

PROBLEM V.

The Altitude and Azimuth of a Star being given, to find the Ship's Latitude.

Given, *Syrius*, Altitude 15°, and Azimuth S. E. by S. ¼ E.

Required, the Latitude.

1. Elevate the North Pole to the Star's Altitude.
2. Fix the Quadrant of Altitude in the Zenith.
3. Bring it to the Star's given Azimuth, *viz.* S. E. by S. ¼ E.
4. Turn the Globe, till *Syrius* meets the Quadrant, which will be in 51° 32′ = the Latitude required.

PROBLEM VI.

The Day of the Month, and Hour of the Night, that a Star is either riſing or ſetting being given, to find the Ship's Latitude.

Given, *October 20th*, and *Arcturus*, riſing at 4 *h.* 30 *m.* A. M.
Required, the Latitude.

1. Rectify the Globe to the Face of the Stars, at the aboveſaid Time, as near as you can, by *Prob.* XXIV. and fix it to the Meridian.
2. Move the Meridian backwards and forwards, till the Star obſerved, comes to the Eaſt-ſide of the Horizon (or Weſt-ſide if ſetting).
3. Obſerve where the Horizon cuts the Meridian under the elevated Pole, which is 52° 32′ N. the Latitude required.

AN

APPENDIX.

Containing the Nature and Uſe of an ORRERY.

THE *Orrery* (by ſome improperly called the *Orrery* Globe) is an Inſtrument contrived to repreſent the Solar Syſtem, or the ſeveral Poſitions of the Sun, Earth, Moon (with the Manner of the Solar and Lunar Eclipſes) and the reſt of the Planets in the ſame Order, as the great Author of Nature has thought fit to place them.

It was the Invention of a late Nobleman in *Ireland*, *viz.* the Lord *Orrery*, Earl of *Orrery*, a Town in that Kingdom; and from the Nobleneſs of the Contrivance, and its contriver together, has ever ſince paſſed by the Name of that Earldom.

The *Orrery*, at firſt, was made with only the Sun, the Earth, and the Moon revolving about it: But this was very ſoon improved, and formed into an Hemiſpherical, and by others into a compleat Armillary Sphere; which laſt exhibits the beſt Idea of the true Syſtem of the World, with the diurnal and annual Motions of the Celeſtial Bodies, and may alſo be rendered capable of ſhewing the third Motion of the Earth, or the Motion of the Poles of the World about the Poles of the Ecliptic, which occaſions the Preceſſion of the Equinoxes; or with more Propriety, the Retroceſſion of the Earth's Nodes in the Space of 25920 Years, which is the great Platonic Year; This is occaſioned by the Stars having a progreſſive Motion from Eaſt to Weſt, at the rate of one Degree of Right Aſcenſion in 72 Years; (for 72 × 360=25920) but the former or Hemiſpheric *Orrery* has been, and is ſtill more in Uſe, as it is eaſier to be managed, and may be purchaſed much cheaper than the other.

Orreries are of two Sorts, *viz.* thoſe moving by Clockwork, and others which move only by the Hand, called manual *Orreries*.

Thoſe moving by Clockwork are extreamly entertaining; for by turning a ſmall Winch, all the Orbs are ſet in Motion at once, *viz.* both circular and central, juſt as they are moved in the Heavens: And all the Phœnomena, or Appearances of the Planets, and their Setellites are exhibited to View, whether direct, ſtationary, or retrograde, in the ſame Manner as they are obſerved from the Earth.

The other Sort called Manual, anſwer the ſame End as the former; but by being moved occaſionally with the Hand only, and not by Clockwork, can't be ſo curious, tho' they may be rendered nearly as Uſeful, by a ſkilful Inſtructor.

Theſe *Orreries* are ſo contrived as to ſhew the *Ptolemaic* and *Copernican* Syſtems at Pleaſure, and thereby inform the Learner how erroneous that Syſtem is, which was firſt invented by *Ptolemy*; and how true and agreeable to Reaſon that Syſtem is, which was firſt invented by *Pythagoras*, and afterwards revived by *Copernicus*. And altho' I have already given ſome Accounts of thoſe Syſtems, prior to the Uſe of the Celeſtial Globe; yet, I ſhall, without referring the Reader back to them, go over them again, with ſome Addition, that I may be the better underſtood concerning the Uſe of the *Orrery*.

Of the SUN.

The great gilded Ball, placed in the Middle of the Inſtrument, repreſents that glorious Luminary of Heaven, and Regent of Day called the Sun, round which all the other Planets move, or by the Hand are made to do ſo.

His direct central Motion is from Weſt to Eaſt, once in 25 Days, and a half on his own Axis; but that Side next to the Earth always appears Retrograde, or from Eaſt to Weſt, becauſe the *Maculæ* thereon are ſeen to move in that Manner; and this without any incongruity, becauſe the oppoſite Sides of any thing circular always move contrary Ways.

Note, Any Point on the Surface of the Sun moves with the velocity of about 4385 Miles per Hour.

His Bulk was formerly ſaid to be 600000 Times greater than the Earth; but now, ſince the laſt Tranſit of *Venus*, he appears to be 1200000 Times greater than the Earth: And as he has no circular Motion, he can have no Orbit.

The *Via Solis*, or Sun's Way, is a common Expreſſion, according to the Appearance of the Sun's Motion, becauſe he ſeems to move in the Ecliptic from Sign to Sign; and therefore he is ſaid to be ſometimes in one Sign, and ſometimes in another: But in reality it is the Earth that moves in the Ecliptic; and then let the Earth be in what Part of the Ecliptic it will, that Sign in the Ecliptic, which is diametrically oppoſite, is the Sign, which the Sun is ſaid to be in, becauſe he appears as if he was in that Sign.

Of MERCURY.

Next to the Sun is the Planet *Mercury*, whoſe circular Motion is ſuch, that the greateſt Elongation, or apparent Diſtance between them, is no more than 28°, *i. e.* if two right Lines be drawn from the Center of the Earth to the Centers of the Sun and *Mercury*, they will make an Angle of 28°; and therefore, becauſe he is always in the Neighborhood of the Sun, he never can be ſeen at Night, but in the *Crepuſculum* or Twilight, *i. e.* a little before the Sun riſes, or a little after he is ſet, according as he is to the Eaſtward or Weſtward of the Sun; or in a total Eclipſe, when the Sun is quite darkened by the Interpoſition of the Moon; or finally, when he makes a Tranſit over the Sun.

His direct Motion is from Weſt to Eaſt, when he is beyond the Sun; but Retrograde, or from Eaſt to Weſt, when he is between the Earth and the Sun; and Stationary, or ſeemingly ſtanding ſtill, when he is about changing theſe Motions one into the other.

According to Sir *Iſaac Newton*, the Heat and Light of the Sun on the Surface of *Mercury* are ſeven Times as intenſe as on the Surface of the Earth, in the Middle of Summer; which as he found by Experiments for that Purpoſe, by a Thermometer, is ſufficient to make Water boil. Such a Degree of Heat, therefore muſt render *Mercury* uninhabitable to Creatures of our Conſtitution: And, if Bodies on its Surface be not inflamed and ſet on Fire, it muſt be becauſe their Degree of Denſity or hardneſs is proportionably greater than that of ſuch Bodies with us.

The Revolution of *Mercury* round the Sun, which is his Year, is performed in 87 Days, 23 *hrs.* 16 *min.* with a Velocity of about 109000 Miles in an Hour. His diurnal Motion or Revolution on his own Axis, which is the Length of his Day, is not yet determined; nor is it certain, whether he has ſuch a Motion round his own Axis or not; tho' it may ſtrongly be preſumed, that he has, as well as the other Planets; otherwiſe one half, at leaſt one third, muſt be in perpetual Darkneſs, or at beſt a kind of Twilight.

What variety of Weather or Seaſons this Planet may be liable to, is as hard to determin as the Length of his Day; inaſmuch as the Inclination of his Axis to the Plane of his Orbit is not known; his Vecinity or nearneſs to the Sun hitherto forbidding all ſuch Determinations.

Mercury changes his Phaſes like the Moon, according to his ſeveral Poſitions, with regard to the Sun and the Earth. It appears full in its ſuperior Conjunctions with the Sun, becauſe the whole illuminated *Hemiſphere* can only be ſeen: In his approach toward the Sun, his Light is falcated or horned, like the New Moon. The Diameter of *Mercury* is 2980 Miles, and his Diſtance from the Sun 36.281.700 Miles; and his Size almoſt 7 Times leſs than the Earth.

The Diameter of the Sun viewed from *Mercury* appears near three Times as big as it appears from the Earth; this Planet being almoſt three Times as near to him as we are; and therefore the Sun's Diſk appears more than ſeven Times as large as to us.

Venus and the Earth, when in oppoſition to the Sun, ſhine with full Orbs, and afford a noble Light to *Mercury*.

Of VENUS.

Next to *Mercury*, in this moſt uſeful Inſtrument, is the Planet *Venus*, which alſo revolves about the Sun from Weſt to Eaſt in her direct Motion; and from Eaſt to Weſt when Retrograde: And tho' ſhe makes a larger Orbit than *Mercury*, yet her greateſt Elongation or apparent Diſtance from the Sun is never more than 48°, and for this Reaſon is never ſeen late at Night.

This Planet being larger than *Mercury*, and when Retrograde alſo much nearer the Earth, is abundantly more refulgent: And according to her Poſition with the Sun, is ſeen ſometimes in the Morning before the Sun riſes, and then ſhe is called *Phoſphorus*, or the Morning Star; and ſometimes in the Evening after the Sun is ſet, and then ſhe is called *Heſperus*, or the Evening Star; and ſometimes ſhe riſes and ſets with the Sun, and then ſhe is neither one nor the other.

In her direct Motion, ſhe is beyond the Sun, but when Retrograde, ſhe is between the Earth and the Sun; and when ſhe is about altering either of theſe Poſitions, ſhe then, for a Time, becomes Stationary.

Venus is eaſily diſtinguiſhed by her Brightneſs and Whiteneſs, which exceeds that of all the other Planets, and which is ſometimes ſo conſiderable, that in a duſky Place, ſhe projects a ſenſible Shadow.

Her periodical Courſe round the Sun, which is her Year, is performed in 224 Days, 17 Hours nearly, with the Velocity of about 80000 Miles in an Hour; and her Motion round her own Axis, which is her natural Day in 23 Hours. Her Diſtance from the Sun is near 68.000.000, or rather 67.795.500 Miles, and Size and Bulk ſomething leſs than the Earth.

Note 1. The relative Diſtances of the Planets from the Sun, according to Profeſſor *Hornſby*'s abſolute Diſtances are as follow; ſuppoſing the Diſtance of the Earth to be 1000,00, *viz.*

Mercury - - - - - - - -	387,10
Venus - - - - - - - - -	723,33
Earth (as above) - - - - -	1000,00
Mars - - - - - - - - -	1523,69
Jupiter - - - - - - - -	5200,98
Saturn - - - - - - - -	9540,07

Hence the *Ratios* of their reſpective Diſtances are eaſier or better diſcovered, than by comparing their abſolute Diſtances. Thus,

Having the relative to find the abſolute (the Earth's abſolute Diſtance by the *Paradox* given, *viz.* 8″,65) it is

as 1000,00 : 387,10 : : 93,726,900 : 36,281,700, or rather 36,281,683$\frac{8}{1}$ == the Diſtance of *Mercury* from the Sun, *Propius veritatem, or nearer the Truth. Sic pro aliis, & inverſè, In like Manner for others, and the Reverſe.*

2. The relative or comparative Diſtance of *Venus* from the Sun, to that of the Earth is $\frac{723.33}{1000.00}$ or not quite $\frac{3}{4}$ *&c.*

Venus is rarely ſeen to ſhine with a full Face, but has Appearances juſt like the Moon, being ſometimes gibbous, ſometimes horned, and ſometimes full; and her illuminated Part is conſtantly turned toward the Sun, ſhe receiving all her Light and Heat from him.

As to the Quantity of Light and Heat, which *Venus* receives from the Sun, they can't be in ſo large a Degree, as on the Surface of *Mercury*, yet they muſt be in a much greater Degree than on the Surface of the Earth; the Orbit of *Venus* being placed between the Orbits of *Mercury* and the Earth. And as her Axis is not quite at right Angles with the Plane of her Orbit, tho' nearly ſo, her Days and Nights all over her muſt be nearly equal, that is, about 11 *hrs.* ½ each, except at her Poles, where it is almoſt always Day: And if, upon the Account of the Sun's ſmall Declination, there ſhould happen to be Night in thoſe Places, it can't be dark, if Refraction be admitted, tho' it is at preſent quite uncertain, whether ſhe is ſurrounded with any *Atmoſphere* or not.

Note, *Mercury* and *Venus* are called inferior Planets, becauſe their Orbits are within that of the Earth.

Of the EARTH and MOON.

Next to *Venus* is the *Earth*, with her Satellite or *Moon* moving round about her, at the ſame Time that ſhe moves round about the Sun.

The *Earth*, in her Motion, makes a regular Orbit, but the *Moon's* Orbit, by her conſtantly attending on the *Earth*, as her ſuperior, becomes very complicated. Regular as to her Motion about the *Earth*, but in deſcribing her Orbit with the *Earth* round the Sun is ſo irregular as to be continually croſſing and recroſſing the Orbit of the *Earth*; conſequently is ſometimes within the *Earth's* Orbit, and ſometimes without it, by which means ſhe is ſometimes (*i. e*, when New) abundantly nearer to the Sun than the Earth is; and at other Times (*i. e.* when Full) abundantly more diſtant and remote.

The Motion of the *Earth* is always direct, or from Weſt to Eaſt, when compared with the Sun, but when compared with the other Planets, the Eye being in any one of them, has like them an apparent retrograde Motion alſo.

The Diſtance of the *Earth* from the Sun is about 93,726,900 Miles, and Bulk 1200000 Times leſs than it. In her circular Motion ſhe revolves about the Sun in 365 *Days*, 5 *hrs.* 48 *min.* 55 *ſec.* (which conſtitutes her Year) at the Rate of about 67256 Miles in an Hour; as has been before obſerved; but in her central Motion, ſhe turns about her own Axis from Weſt to Eaſt once in 24 Hours, which makes her natural Day.

The Quantity of Light and Heat, which are received on her Surface from the Sun, are not always the ſame, but variable. In ſome Places, as at the Equator, it is very hot; in others, as at the Poles, it is always very cold; in other Places, as at the *temperate Zones*, it is ſometimes hot, ſometimes cold, and ſometimes at a Medium.

The *Moon* is an Attendant upon our *Earth*, whom ſhe Reſpects as a Center, and in whoſe Neighborhood ſhe is conſtantly found.

She is known to have a threefold Motion, *viz.* Central, Circular, and mixed Circular.

1. The Moon has a central Motion, as ſhe turns about her own Axis, which is performed once in 27 Days, 7 *hrs.* and 48 *min.* which conſtitutes her natural Day.

2. She has alſo a circular Motion round about the *Earth*, which is performed in the ſame preciſe Time. And,

3. She has a mixed circular Motion, as ſhe is carried, with the *Earth*, round about the Sun, with an inconceivable Impetus or Force.

As to her other different Motions, we are to obſerve, that at the Time of New Moon, ſhe is with us by Day, and then ſhe is between the Earth and the Sun, moving in a direct Motion; but at the Time of Full Moon, ſhe is with us by Night, and then her Motion is retrograde, becauſe the Earth is then between her and the Sun. When ſhe is in her Quadratures, ſhe is with us partly by Day and partly by Night; ſhe being in her firſt Quarter, Eaſtward of the Sun, and in her laſt Quarter, Weſtward of it, and at thoſe Times is then in or near the Earth's Orbit. And tho' in her direct Motion, ſhe apparently moves retrograde or from Eaſt to Weſt, yet that is owing to the Earth's Revolution on its own Axis from Weſt to Eaſt, and not from the real Motion of the Moon that Way, notwithſtanding, that ſhe riſes in the Eaſt and ſets in the Weſt.

The Orbit of the Moon is an Elipſis, in which ſhe is retained by the force of Gravity. Her mean Diſtance from the Earth is 240000 Miles; the Earth's Semidiameter being 3982 Miles. The Moon's apparent Semidiameter at her mean Diſtance is 15′ 38″ whence her Diameter in Miles is 2192; therefore the Face of the Earth, as it appears to the Lunarians, is to the Face of the Moon, as it appears to us, as 12.2 is to 15 and the Bulk of the Earth to that of the Moon, as 50 to 1 nearly.

The Moon has conſtantly the ſame Side turned to the Earth, hence the Inhabitants of her other Side, who have a Mind to ſee our Earth, which is a Moon to them, muſt travel for it, or not ſee that Sight. And, if both Bodies have the ſame Power of Reflexion, according to the Magnitudes of their Surfaces, the Earth will ſend back to the Moon 15 Times more Light than ſhe receives from it, as the Surface appears 15 Times greater to the Lunarians.

As the Moon moves in an Ellipſe (equally about her Axis) yet an apparent Inequality is produced by her ſeeming to move ſometimes from Eaſt to Weſt, and again from Weſt to Eaſt, ſo that ſome denſe Parts of her Weſtern Limb (before inviſible) now become Viſible, and thus alternates and returns again *in ſtatu quo*, and this is called her Libration. This happens every Revolution. *Vide Keil's Aſtron. Lect.* p. 103.

The Quantity of Light and Heat, which the Moon receives from the Sun, is abundantly more variable than that which the Earth receives: For, when the Moon is in Conjunction with the Sun, *i. e.* New Moon, ſhe is then neareſt to the Sun, and conſequently receives more Light and Heat, at that Time, than the Earth does: When ſhe is in Oppoſition to the Sun, *i. e.* Full Moon, ſhe is then fartheſt from the Sun, and conſequently has not the Light and Heat ſo ſtrong as the Earth has: And when ſhe is in her Quadratures, moving in the Earth's Orbit, ſhe then has a Quantity of Light and Heat between the two forementioned Extreams, and enjoys much the ſame Light and Heat as the Earth does.

The Moon is a denſe opake Body, furniſhed with huge Mountains, deep Vallies and large Seas; having no Light, but what ſhe receives from the Sun, and reflects back again. Hence the Eye (without a Teleſcope, but better with one) ſees ſome Parts of the Moon's Face darker than others, which are called *Maculæ* or Spots, and others again more lucid and bright. The *Maculæ* are ſome moveable, and ſome immoveable. The moveable ones are Shadows of Mountains, being ſeen ſometimes in one Poſition, and ſometimes in another, according as the Moon is Eaſtward or Weſtward of the Sun. The immoveable ones are Seas and large Lakes, becauſe being tranſparent, they abſorb a great Part of the Rays of Light, and reflect very little.

The lucid or bright Parts of the *Maculæ*, are Iſlands and Peninſulas; and as ſome of the lucid Parts of the *Maculæ* are brighter than others, they muſt be very high denſe Rocks and Promontories. The other lucid Parts, which are very large, are Continents, which by their ſolidity admit of no Rays of Light beyond their Surfaces, and therefore the Light is the more ſtrongly reflected.

Some few have argued as follows, *viz.* 'The Moon is encompaſſed 'with an heavy and elaſtic *Atmoſphere*, wherein Vapours, and other Ex'halations aſcend, and whence they return in the forms of Dew and Rain.

Hence it appears, that this Planet is a Body, in all Reſpects, like our Earth, and fitted for the ſame Purpoſes. It is denſe, opake, has Mountains and Vallies, Seas with Iſlands, Peninſulæ, Rocks and Promontories; a changeable *Atmoſphere*, wherein Vapours and Exhalations riſe and fall; it has Day and Night; a Sun to illuminate the one, and our Earth, which ſerves as a Moon, ſometimes to illuminate the other; it has Summer and Winter, Winds, Rain, Miſts, Froſt and Snow; and from the Inequalities of her Surface has Lakes, Rivers, Springs, *&c.*

‘ Now Nature, it is well known, produces nothing in vain. Rains, and Dews fall on our Earth to make Plants vegetate; and Plants take Root, grow, produce Seeds, and Fruits for Animals to feed on.—— But Nature is ſtill uniform and conſiſtent with herſelf; and like Things ſerve for like Ends. Why then may there not be Plants for Animals in the Moon; and to what other Purpoſe ſo nice a Proviſion for them?’

‘ Theſe Arguments will receive new Force, if it be conſidered, that our Earth itſelf is a Planet; and when viewed from the other Planets, it appears in one like the Moon, in another like *Venus*, in another like *Jupiter*, *&c.* a Similitude between the Planets, both optical and phyſical, being a ſtrong Preſumption, that their Furniture is alike alſo’.— *See Chamb. Dictionary, under the word Moon.*

But however all this is, our preſent *Aſtronomers* do not believe, that there are any Seas in the Moon; the antient *Philoſophers* indeed, ſuppoſed the dark Spots to be Seas, but the Moderns, with better Teleſcopes imagin them to be deep Pits and Caverns, whoſe Shadows fall within them.—— *Keil's Aſtron. Lect.* p. 108. Again,

Some few have mentioned an *Atmoſphere*, but far the greateſt Part of *Aſtronomers* have been of a contrary Opinion: for, if there was an *Atmoſphere* any thing like ours, it would moſt certainly obſcure the fixed Stars, in the Moon's appulſe to them; but this has never yet been obſerved to be the Caſe. On the contrary, they preſerve their Luſtre intirely to the Moment of their Occultation, and diſappear inſtantaneouſly; and as inſtantaneouſly recover their Light, when they appear again on the other Side. Now, if there be no *Atmoſphere*, there ſhould not be any Clouds, Rain, Hail, Snow, or other Meteors expected. However; if there be any ſuch Thing, it muſt be vaſtly more rare than our terreſtrial *Atmoſphere*, and yet perfectly ſufficient, not only for the Being, but for the well-being of the Inhabitants, and all productions of that Planet. —— Again,

That the Body of the Moon (and other Planets) is of a terreſtrial Nature, admits of no Diſpute, but the Qualities of their Compoſitions, and the Kind of Inhabitants are at preſent out of our Sphere of phyſical Knowledge. *Mountaine.*

Of MARS.

Next to the Earth is the Planet *Mars*, moving in his Orbit round the Sun, in a direct Motion from Weſt to Eaſt, but in his retrograde Motion from Eaſt to Weſt.

Whether he has any ſecondary or Moon revolving round him or not, is not known; however none, as yet, has been diſcovered, for which Reaſon it is thought by ſome, that he has no Attendant of that kind.

When *Mars* moves in a direct Motion, he is then, with Reſpect to the Earth, beyond the Sun, and with us by Day, and therefore cannot be ſeen, except it ſhould happen at a total Eclipſe of the Sun, but when his Motion is retrograde, then it is that he is neareſt the Earth, and with us by Night.

His Diſtance from the Sun is about 143,818,000 Miles; and Size almoſt eight Times leſs than the Earth. He revolves round the Sun in 1 *y.* 321 *d.* 23 *h.* 27 *m.* which is his Year, with a Volocity of about 55000 Miles in an Hour; but round his own Axis in 24 *h.* 40 *m.* which is his natural Day.

Note, The Diameter of the Earth to that of *Mars*, is nearly double (the Earth being 7970 Miles, and *Mars* 4400 Miles) and therefore the Magnitude of the firſt to that of the laſt, ſhould be nearly as 8 to 1.

Mars always appears with a ruddy troubled Light; whence *Aſtronomers* conclude that he is encompaſſed with a thick cloudy *Atmoſphere*, which, by diſturbing the Rays of Light in their Paſſage, and re-paſſage thro' it, occaſion that Appearance.

This Planet's mean Diſtance from the Sun is to the Diſtance of the Earth from the Sun, as 1.5 to 1: ſo that a Man placed in *Mars*, would ſee the Sun's Diameter leſs, by one-third than it appears to us; and conſequently the Degree of Light and Heat, which *Mars* receives from the Sun is leſs, by one-third than thoſe received by the Earth. Again;

Mars is five Times nearer to us, when he is in Oppoſition, than when he is in Conjunction with the Sun. And therefore, ſince the viſible Diſk and Luſtre of a Planet increaſes in a duplicate Proportion of that wherein the Diſtance is diminiſhed, *Mars* will appear 25 Times bigger and brighter when he is in Oppoſition to, than when he is in Conjunction with the Sun. *Keil's Aſtron. Lect. p.* 176.

The Axis of the diurnal Motion of *Mars* is nearly at right Angles with the Plane of his Orbit; hence it appears, that in one and the ſame Place, on his Surface there is but little Variety of Seaſons, or ſcarce any Difference of Summer and Winter. However, Places ſituated in different Latitudes; *i. e.* at different Diſtances from his Equator, will have different Degrees of Light and Heat, on account of the different Inclination of the Sun's Rays to the Horizon; as it is with us, when the Sun is in the Equinoxes: And for the ſame Reaſon alſo, the Days and Nights are equal; *i. e.* 12 *hrs.* 20 *min.* each, except at his Poles, where it is always, or for the moſt part Day; at leaſt it is never Night, becauſe the Sun is always in the Horizon, or but very little depreſt below it.

Note, This Appearance is nearly the ſame in the other Planets, according to the inclinations of their Planes, which are but little.

Of JUPITER.

Next to *Mars* is the Planet *Jupiter* revolving round the Sun, from Weſt to Eaſt, in his direct Motion, but in his retrograde Motion from Eaſt to Weſt.

Jupiter is the biggeſt of all the Planets; and its Revolution about its Axis at the Equator is the ſwifteſt, it being performed in 9 *hrs.* 56 *min.*—Now, if the Earth at the Equator, runs 15 nautical Miles in a Minute, with what incredible Swiftneſs muſt this Planet turn at its Equator, which is 254571 Miles in Circumference, and turns in 9 *hrs.* 56 *min.* that is 427 Miles in 1 Minute = 7 Miles in 1 Second; which is thus found.

h. *m.* *m.* 60
9 56 = 596; and 596) 254571 (427 + Miles in 1 Minute.
7 + Miles in 1 Second.

This Planet has 4 Satellites, or Moons, moving round him from Weſt to Eaſt, which with him are all carried round the Sun, making ſuch unequal and irregular Orbits as our Moon does, they being ſometimes within the Orbit of their Primary, and ſometimes without it. Theſe Moons are all Teleſcopic, and therefore none of them are capable of being diſcovered by the bare Eye.

Theſe 4 Moons, or little Stars were firſt diſcovered in *Italy*, in the Year 1610, by *Galilæus*, an *Italian Aſtronomer*, who called them *Aſtra medicæa, medicæan* Stars, but we the Satellites of *Jupiter*.

After him M. *Caſſini*, a *French Aſtronomer*, determined their periodical Times and Diſtances from *Jupiter* in Semidiameters: But, as theſe Satellites have been very narrowly examined, by ſome eminent *Aſtronomers* of our own Time, as well, as by Monſieur *Caſſini*, I ſhall here give their periodic Revolutions, according to the late Mr. *Hodgſon's* Theory of them, compoſed from Mr. *Flamſteed's* Obſervations and Tables, as communicated by my preſent worthy Friend, *William Mountaine*, Eſq. F. R. S.

	d.	*h.*	*m.*	*ſ.*		
1 Satellite	1	18	28	35	5.965	Diſtances in Semidiameters, or greateſt Elongations from *Jupiter's* Body.
2 - - - -	3	13	17	53	9.494	
3 - - - -	7	3	59	37	15.141	
4 - - - -	16	18	5	4	26.630	

Beſides theſe periodic Revolutions about their Primary, they ſeem to revolve about their own Axes, as the other Planets do: And this appears from the ſame Satellite's ſhining brighter at one Time than at another; and that when one of them hath appeared with its utmoſt Splendor, the Light of another has been conſiderably diminiſhed; from whence it is further probable, that ſome Part of their Surfaces do very faintly, if, at all, reflect the ſolar Rays to us, as has been taken Notice of by ſeveral *Aſtronomers*.

This Planet has a Phenomenon, peculiar to itſelf, *viz.* the *tria Cingula*, or three Girdles or *Zones*, commonly called *Jupiter's* Belts, which thro' a Teleſcope, make a very pleaſing Appearance. According to Sir *Iſaac Newton*, they are formed in his *Atmoſphere*, in which are ſeveral *Maculæ* or Spots; from the Motion of which, the Motion of *Jupiter* round his Axis is ſaid to have been firſt determined.

In his direct Motion, he is with us by Day, and is beyond the Sun, and conſequently at his greateſt Diſtance from us; but in his retrograde Motion, he is with us by Night, is neareſt to us, and it is then only that he can be ſeen by us.

His Diſtance from the Sun is 487,472,000 Miles, and Bulk above 1200 Times greater than the Earth. He revolves about the Sun in 12 Years nearly, which is his Year; and about his own Axis in 9 *hrs.* 56 *min.* which is his natural Day.

The Day and Night of *Jupiter* are very near of the ſame Length all over his Surface, *viz.* 6 Hours each, except at his Poles, where it is continual Day, at leaſt never Night admitting Refraction, as formerly mentioned; the Reaſon of which is, becauſe the Axis of his diurnal Rotation is nearly at right Angles, with the Plane of his Orbit.

> *Note*, Mr. *Gregory* computes the Diſtance of *Jupiter* from the Sun to be above five Times as great as that of the Earth from the Sun; whence he gathers that the Diameter of the Sun, to an Eye placed in *Jupiter*, would not be above a fifth Part of what it appears to us; and therefore his Diſk would be 25 Times leſs, and his Light and Heat in the ſame Proportion.

Of SATURN.

Next to *Jupiter* and his Satellites is one more, and that is the utmoſt of our Syſtem, that we know of; *viz.* the Planet *Saturn* revolving like the reſt, round the Sun from Weſt to Eaſt in his direct Motion; but in his retrograde Motion from Eaſt to Weſt.

Jupiter has 5 Satellites or Moons, all teleſcopic, moving round him from Weſt to Eaſt; and as they move round the Sun with their Superior, muſt make irregular Orbits in that particular; they being ſometimes within the Orbit of their own Planet, and ſometimes without it.

There is a very particular Phenomenon belonging to this Planet; *viz.* a large broad and lucid Ring of about 21000 Miles broad, at ſuch a Diſtance from him, as is equal to its breadth, inſomuch, that ſometimes, with a good Teleſcope, that Diſtance is very perceptible, and the Eye that views *Saturn* and his Ring, can alſo ſee the Diſtance between them, and look thro' the Space. The *Rev.* Mr. *Pound*, makes the whole Diameter of the Ring, to the Diameter of *Saturn*, as 7 to 3.

In his direct Motion, he is like *Jupiter*, fartheſt from us, being then beyond the Sun, and with us by Day; but in his retrograde Motion, he is neareſt to us, and is Viſible, being with us by Night, the Earth being then between him and the Sun.

His Diſtance from the Sun is 894,162,000 Miles; and his Bulk is more than 1488 Times greater than the Earth. He revolves about the Sun in the Space of 30 Years nearly, which is his Year, with the Velocity of about 22000 Miles *per* Hour; but in what Time about his own Axis, no body can tell; his great Diſtance from the Earth, and want of *Maculæ* (at leaſt none can be ſeen by our beſt Teleſcopes) put it out of the Power of the ableſt *Aſtronomers* to determine, whether he has any ſuch Rotation or not (tho' it may be ſuppoſed he has) and therefore the Length of his natural Day cannot be adjuſted.

The Diſtance of *Saturn* from the Sun, being ten Times greater than that of the Earth from the ſame; it is found, that the apparent Diameter of the Sun ſeen from him, will not exceed three Minutes, which is but little more than twice the Diameter of *Venus*. The Sun's Diſk therefore to an Inhabitant of *Saturn*, will appear 100 Times leſs than it does to us, and both its Light and Heat will be diminiſhed in the ſame Proportion; and therefore the warmeſt Regions in *Saturn*, even under his Equator, are much colder than our *frigid Zones*.

The periodical Times of the Satellites of *Saturn*, and their Diſtances from him in his Semidiameters, according to Dr. *Keil*, are as follow; *viz.*

		d.	*h.*			
1	Satellite	1	21	Diſtance	$4\frac{3}{8}$	Semidiameters
2	- - - -	2	17	- - - -	$5\frac{3}{5}$	ditto
3	- - - -	4	12	- - - -	8	ditto
4	- - - -	16	0	- - - -	18	ditto
5	- - - -	79	8	- - - -	54	ditto

Note, Other *Aſtronomers* have given us their periodic Revolutions, both of *Jupiter* and *Saturn*, but they all differ a little in their Computations; and no wonder, ſince different Eyes and different Inſtruments may be the Occaſion of different Computations: But the grand Cauſe of theſe Differences ariſes from the Difficulty there is in meaſuring, to the greateſt Exactneſs, the Diameters of the primary Planets. However, this is not ſo eſſential as the Proportions between the Diſtances, and thoſe are now pretty well adjuſted.

Of COMETS.

Beſides the ſeveral Planets beforementioned, there are other Sorts uſually called *Comets*, which are heavenly Bodies in the planetary Region, appearing ſuddenly, and after ſome Days or Weeks Appearance, again diſappear; and during the Time of their Appearance move in very long and narrow Ellipſes, or excentric Orbits, being ſometimes ſo near the Sun as to be within the Orbit of *Mercury*; and ſometimes ſo remote from him, as to be without the Orbit of *Saturn*. Sir *Iſaac Newton* defines them after the following Manner.

" *Comets* (ſays that great Author) are compact, ſolid, fixed and durable
" Bodies, or a kind of Planets, which move in very oblique Orbits, every
" Way with the greateſt Freedom, perſevering in their Motions, even
" againſt the Courſes and Directions of the Planets; and their Tails are
" very ſlender Vapours, emitted by the Head or *Nucleus* of ſuch *Comet*,
" ignited, or heated by the Sun".

Thoſe long Tails, or Trains of Light are always oppoſite to the Sun, which are of a fainter Luſtre the farther they are from their own Bodies.

Comets, are popularly diſtinguiſhed into three Kinds, *bearded*, *tailed*, and *hairy*; tho' in effect, this Diviſion rather relates to the ſeveral Circumſtances of the ſame *Comet*, than to the Phenomena of ſeveral.

Thus, when the *Comet* is Eaſtward of the Sun, and moves from it, the *Comet* is ſaid to be *bearded*, becauſe the Light marches before it in Manner of a *Beard*.

When the *Comet* is Weſtward of the Sun, and inclines toward it, the *Comet* is ſaid to be *tailed*; becauſe the Train follows it in Manner of a Tail.

Laſtly, when the *Comet* and the Sun are diametrically oppoſite (the Earth being between them) the Train is hid behind the Body of the *Comet*; excepting a little that appears around it, in form of a Border of Hair: hence called *hairy*. But, at all Times, this Tail or Train of Light is ſo extremely thin and fine, that the Stars are viſible thro' it.

Their Courſes are not among the fixed Stars, but among the Planets; and as the Motion of the Earth either conſpires with them, or goes againſt them, their Appearances, with regard to the Earth, muſt be changed; and like Planets they muſt ſometimes appear ſwifter, ſometimes ſlower, and ſometimes Retrograde.

Now, if Planets (like *Mercury)* are the more Denſe, by how much the nearer they are to the Sun, that they may be the better enabled to reſiſt, or endure the Heat of the ſolar Rays; and on the other hand (like *Saturn*), are abundantly leſs denſe, by how much the farther they are from him, that they may the better receive the ſolar Rays to vivify and enliven them; what muſt be the Mechaniſm of a *Comet*, which ſometimes receives a greater Degree of Light and Heat than *Mercury*, and afterward in its Paſſage thro' its Orbit, enjoys a leſs Degree of Light and Heat than *Saturn!* And what muſt its Inhabitants be, who can endure ſuch an inconceivable Light and Heat at one Seaſon of its Year; and ſuch an inexpreſſible Cold at another! *Think Reader, and be aſtoniſhed at the wonderful Works of the Almighty.*

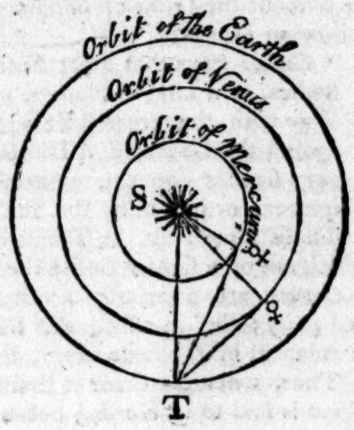
Of the Diſtances of the PLANETS from the SUN.

The Diſtances of the Planets from the Sun are of two Sorts; *viz.* Relative and Abſolute.

1. *Of the relative Diſtances.*

The *relative* Diſtances of the Planets from the Sun, and likewiſe from each other, are determined by the following Methods; *viz.*

The Diſtances of the two inferior Planets ☿ and ♀ from the Sun, in Reſpect of the Earth's Diſtance from him, is had by obſerving their greateſt Elongations from the Sun, as they are ſeen from the Earth.



The greateſt Elongation of *Venus* is found by Obſervation, to be about 48°, which is the Angle S T ♀, whence, by the known Rules of Trigonometry, the Proportion of S ♀ (which is the mean Diſtance of ♀ from the Sun) to S T, which is the mean Diſtance of the Earth from him, may be eaſily found; thus,

Radius - - - - - - -	10.
To S T = 1000 - - - -	3.
So is S. of S T ♀ = 48° -	9.8710735
To S ♀ = 743. for ♀'s Diſt.	2.8710735 rejecting Decimals.

After the ſame Manner, in the Angle S T ☿, may be found the Diſtance of ☿ from the Sun = S ☿. And, if the mean Diſtance of the Earth from the Sun = S T be made 1000, the mean Diſtance of *Venus* from the Sun = S ♀ will be 743, and of *Mercury* = S ☿ = 358. And if the Planets moved round the Sun in Circles, having him for their Center, the Diſtances here found, would be always their true Diſtances; But as they move in Ellipſes, their Diſtances from the Sun will be ſometimes greater and ſometimes leſs. Their Excentricities are computed to be as follows; *viz.*

Excent^{s}. of
Mercury - - 80
Venus - - - 5
Earth - - - 169
of the Parts abovementioned.

Note 1. An *Ellipſis* is an oval Figure of no determinate Size, but has its tranverſe and conjugate Diameters (each of them) ſometimes of one Length, and ſometimes of another; and the nearer the conjugate or ſhorter Diameter approaches to the tranverſe, or longer Diameter, the nearer ſuch an *Ellipſis* approaches to a Circle.

2. For the Formation of an *Ellipſis*, let two Pins be faſtened upwright of any convenient Diſtance, at Pleaſure upon any Plane; alſo, let a Thread be tied looſely about them, which, when doubled, is of greater Length than the Diſtance of the Pins: Then let a Pencil ſtretch out the ſaid Thread, and paſs along as the Thread will permit: the Figure thus made is an *Ellipſis*.

3. The two Points, where the Pins ſtood, are called the *Foci* of that *Ellipſis*, or Places, where the Rays reflected from all the Parts of thoſe Curves do concur and meet.

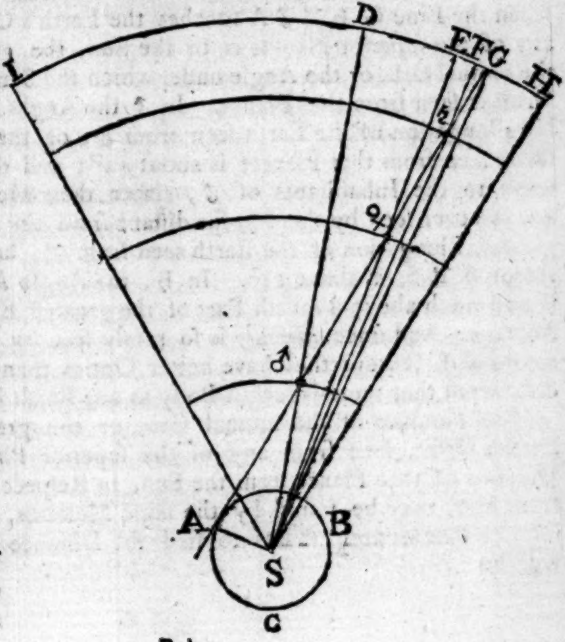
4. The Orbit of every Planet has the Sun in one of its *Foci*.

5. Half the Diſtance between the two *Foci* (which is the ſame with the Point of Interſection of the two Diameters of ſuch an *Ellipſis*, and of equal Diſtance from either *Focus*) is called the *Excentricity* of ſuch a Planet's Orbit; that Point not being the Center of the Orbit, tho' it is the middle of each Diameter.

6. The *Excentricity* is different in all the Planets: and in little Schemes, or Inſtruments made to repreſent the planetary Syſtem, the greateſt *Excentricity* is ſo ſmall, that it cannot well be conſidered otherwiſe than as the Center of a Circle, and therefore the Orbits of all the Planets are regarded only as Circles.

The Diſtances of the ſuperior Planets; *viz.* ♂, ♃, and ♄, are found, by comparing their true Places, as they are ſeen from the Sun, with their apparent Places, as they are ſeen from the Earth.

Let S be the Sun, the ſmall Circle A B C the Earth's Orbit; A G a Line, touching the Earth's Orbit, in which the ſuperior Planets are ſuppoſed to be ſeen from the Earth in the Points of their Orbits ♂, ♃, ♄; and let I, D, E, F, G, H, be a portion of a great Circle in the Heavens, at an infinite



Diſtance: Then the Place of ♂ ſeen from the Sun is D, which is his true or heliocentric Place; but, from the Earth at A, he will be ſeen in G, which is called his apparent or geocentric Place. So likewiſe ♃ will be ſeen from the Sun in E, and ♄ in F, their heliocentric Places; but a Spectator from the Earth at A will ſee them both in the Heavens in the Point G, which is their geocentric Place. The Arches D G, E G, and F G being the Differences between the true and apparent Places of the ſuperior Planets are called the *Parallaxes* of the Earth's annual Orb, as ſeen from thoſe Planets.

> *Note*, Parallax is the Diſtance between two Places in the Heavens, in which the ſame Object is ſeen, when viewed at two different Places, either from the Earth, or from any other Planet. Or,
>
> It is the Difference between the true and apparent Diſtance of any heavenly Body from the Zenith of ſuch Planet's true Place; being eſtimated from the Center of the Earth, and its apparent Place viewed from any Spot on the Surface.

If thro' the Sun you draw S H parallel to A G, the Angles A ♂ S, A ♃ S, and A ♄ S will be reſpectively equal to the Angles D S H, E S H, and F S H; and the Angle A G S is = the Angle G S H, whoſe Meaſure is the Arch G H, which therefore will be the Meaſure of the Angle A G S, the Angle under which the Semidiameter A S of the Earth's Orbit is ſeen from the ſtarry Heavens. But this Semidiameter is nothing in Reſpect of the immenſe Diſtance of the Heavens or fixed Stars; for, from thence, it would appear under no ſenſible Angle, but look like a Point; and therefore, in the Heavens, the Angle G S H, or the Arch G H vaniſhes, and the Points G and H coincide; and the Arches D H, E H, and F H, may be conſidered as being of the ſame bigneſs with the Arches D G, E G, and F G, which are the Meaſures of the Angles A ♂ S, A ♃ S, and A ♄ S, which Angles are nearly the greateſt Elongation of the Earth from the Sun, if the Earth were obſerved from thoſe reſpective Planets, when the Line G ♄ ♃ ♂ A touches the Earth's Orbit in A. The nearer any of the ſuperior Planets is to the Sun, the greater is the Parallax of the annual Orb, or the Angle under which the Semidiameter of the Earth's Orbit is ſeen from that Planet. In ♂ the Angle A ♂ S (which is the viſible Elongation of the Earth ſeen from ♂, or the Parallax of the annual Orb, ſeen from that Planet) is about 42°; and therefore the Earth is always to the Inhabitants of ♂, either their Morning or Evening Star; and is never ſeen by them ſo far diſtant from the Sun as we ſee ♀. The greateſt Elongation of the Earth ſeen from ♃, being nearly equal to the Angle A ♃ S, is about 11°. In ♄, the Angle A ♄ S is about 6°, which is not much above a fourth Part of the greateſt Elongation we obſerve in *Mercury:* And ſince *Mercury* is ſo rarely ſeen by us, probably the *Aſtronomers* of ♄ (except they have better Optics than we have) have not yet diſcovered that there is ſuch a Body as our Earth in the Univerſe.

The Parallax of the annual Orb, or the greateſt Elongation of the Earth's Orbit, ſeen from any of the ſuperior Planets being given; the Diſtance of that Planet from the Sun, in Reſpect of the Earth's Diſtance from him, may be found by the ſame Methods, as the Diſtances of the inferior Planets are. Thus to find the Diſtance of ♂ from the Sun, it will be

As the Sine of the Angle S♂A :
Is to Radius : :
So is the Diſtance A S (the Diſtance of the Earth from the Sun) :
To S♂ (the Diſtance of *Mars* from the Sun),

Or thus,

As the Sine of S♂A = 42° - - - 9.8255109
Is to Radius - - - - - - - - 10.
So is A S = 1000 - - - - - - 3.
To S♂ = 1494. - - - - - - - 3.1744891

after the ſame Manner, the Diſtances of ♃ and ♄ are to be found.

The mean Diſtance of the Earth from the Sun being made 1000, the mean Diſtances of the ſuperior Planets from the Sun are, *viz.*

		and the *Excentricity*
♂	1494	141
♃	5240	250
♄	9566	547

to or from which mean Diſtances, if you add or ſubtract their *Excentricities*, you will have the greateſt or leaſt Diſtances of thoſe Planets from the Sun. Thus the mean Diſtance of ☿ is 358, and its *Excentricity* is 80; then,

358 — 80 is = 278 its leaſt Diſtance, and,
358 + 80 is = 438 its greateſt Diſtance, &c.

2. Of the abſolute Diſtances.

The Periods of the Planets round the Sun; their Diſtances from him; their Axes or Diameters; their Velocities round their own Axes; their Bulk, or the Number of Times they are greater or leſs than the Earth, have already been mentioned, and are all of them found in the following Manner, *viz.*

1. The Revolutions of the ſeveral Planets round the Sun, and alſo round their own Axes, are obtained by repeated Obſervations; very good Teleſcopes; ſtrong Eyes; and much Patience.

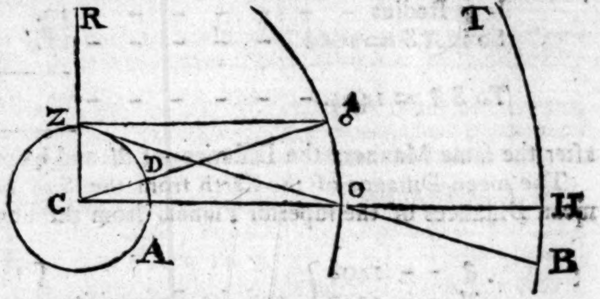
2. To find the abſolute Diſtances of the Planets from the Sun, in ſome determinate Meaſure, there muſt be ſomething given, whoſe Meaſure is known. Now the Circumference of the Earth is divided into 360°, and each of theſe Degrees into 60 nautical Miles, or 69.5 Geographical Miles; ſo that the whole Circumference, contains 21600 nautical Miles, or 25020 Geographical Miles; and by the known Proportion for finding the Diameter of a Circle from its Circumference, *viz.*

22 : 7 : : Circumference : Diameter

the Earth's Diameter is found to be 6872 nautical Miles, or 7960.9 Geographical Miles; and its Semidiameter 3436 nautical Miles, or 3980.45, Geographical Miles.

The Parallax of the Earth's Semidiameter, or the Angle under which it is ſeen from a certain Planet, may be found by comparing the true Place of the Planet, as it would be ſeen from the Center of the Earth (which is known by Computation) with its apparent Place, as it is ſeen from ſome Point on the Surface of it.

Let C Z A be the Earth; Z C its Semidiameter; O ſome Planet, and T H B an Arch of a great Circle in the Heavens, at an infinite Diſtance. Now the Planet O, will appear from the Earth's Center C in the Point of the Heavens H; but a Spectator at the Point Z, upon the Earth's Surface, will ſee the ſame Object in the Point of the Heavens B; and the Arch H B, the Difference, is equal to the Angle H O B = Z O C the Parallax; which being known, the Side C O the Diſtance of the Planet from the Center of the Earth, at that Time, may be eaſily obtained. This Diſtance of the Planet from the Earth, if it be determined, when the Centers of the Sun, of the ſaid Planet, and of the Earth, are in the ſame right Line, we have the abſolute Diſtance of the Planet's Orbit from the Earth's Orbit in known Meaſure: then it will be



As the relative Diſtance between the Earth's Orbit and the Planet's Orbit:

Is to the relative Diſtance of the ſaid Planet from the Sun : :

So is the Diſtance of the Planet's Orbit from the Earth's Orbit in known Meaſure:

To the Diſtance of the ſaid Planet from the Sun in the ſame Meaſure, which being known, the Diſtances of all the other Planets from the Sun may be found. For it will be

As the relative Diſtance of any Planet from the Sun:
Is to the Diſtance from him in a known Meaſure : :
So is the relative Diſtance of any other Planet from him:
To its Diſtance in the ſame Meaſure.

This may be done by finding the Diſtance of the Planet ♂, when he is in Oppoſition to the Sun, after the ſame Manner as we find the Diſtance of a Tree, or the like, at two Stations.

Let ♂ be *Mars*; D the Point on the Earth's Surface, where ♂ is vertical in the foregoing Scheme, when he is in Oppoſition to the Sun (which may be exactly enough found by Calculation) at which Time, let an Obſerver at the Point Z (whoſe Situation from D muſt be known) take the Altitude of ♂, whoſe Complement will be the Angle ♂ Z R; then in the Triangle ♂ Z C are given the Angle ♂ Z C, alſo the Angle C (whoſe Meaſure is the Arch D Z) and conſequently the Angle Z ♂ C, which is the Supplement of the other two Angles to 180°; the Parallax, and alſo the Side Z C the Semidiameter of the Earth; by which, we may find

C ♂ the Diſtance of ♂ from the Earth: But the extreme nicety required in this Obſervation makes it very difficult to determin the exact Diſtances of the Planets from the Sun; and therefore the celebrated Dr. *Halley*, has, in the Philoſophical Tranſactions, ſhewed us a more certain Method for finding the Diſtances of the Planets; which is by obſerving the Tranſit of *Venus* over the Sun.

Note 1. The Diſtances of the Planets one from another, may be obtained by Subtraction: For, if the Diſtance between *Mercury* and the *Sun*, be taken from the Diſtance between *Venus* and the *Sun*, the Difference will be the Diſtance between *Mercury* and *Venus*; and ſo of any other two Planets. But this is to be ſuppoſed only when they are in a right Line paſſing thro' their Centers and that of the Sun.

2. On the *Orrery* their Diſtances are thus; ſuppoſing the Diſtance of the Earth from the Sun to be divided into ten equal Parts, then

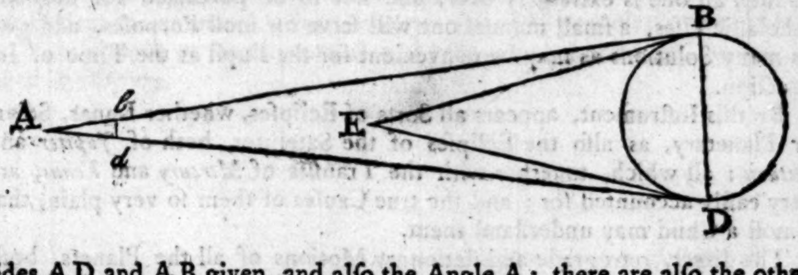
Mercury will be about 4 of thoſe Parts
Venus - - - - 7
Earth (as above) - 10
Mars - -- - - 15
Jupiter - - - - 52, and
Saturn - - - - 95.

3. *To find the Diameters of the Planets, and thence their Magnitudes.*

The Eye judgeth of the Magnitudes of diſtant Objects, according to the Quantities of the Angles under which they are ſeen (which is called the apparent Magnitudes) and thoſe Angles appear greater or leſs in a certain Proportion to their Diſtances: Wherefore the Diſtances of the Planets from the Earth, and their apparent Diameters being given, their true Diameters and from thence their Magnitudes) may be found.

The apparent Diameters of the Planets, are found, by a Teleſcope, having a Machine fixed to it, called a *Micrometer*.

Let B D, or the Angle B A D be the apparent Diameter of any Planet, and A B or A D (which by Reaſon of the great Diſtances of the Planets in Reſpect of their Magnitudes) may be conſidered as the Diſtance of the ſaid Planet from the Obſerver. Now in the Triangle A B D, having the Sides A D and A B given, and alſo the Angle A; there are alſo the other Angles B and D (becauſe the Sides A B and A D are equal) whence the Side B D the Diameter of the Planet, may eaſily be found by Trigonometry.



From hence it appears, that the ſame Body at different Diſtances, will ſeem to have very different Magnitudes. Thus the Diameter B D will appear, from the Point E, to be a great deal larger than from the Point A; and as the Point E is placed in the Center between A and the Object, it will be twice as large; for the Angle at the Center is equal to twice the

Angle at the Circumference, ſtanding upon the ſame Arch or Chord.— It alſo follows, that a ſmall Body, when at no great Diſtance from us, may appear to be equal, or even to exceed another at a greater Diſtance, tho' immenſely bigger. Thus *b d* appears, under the ſame Angle, of the ſame bigneſs from the Point A, that the Line B D doth, tho' one vaſtly exceeds the other. And this is the Reaſon, why the Moon, which is much leſs than any of the Planets, appears to us, vaſtly bigger than either of them; and even to equal the Sun himſelf, which is many hundred thouſamd Times greater.

4. *To find the Solidities of the Sun und Planets.*

(uſe the following Proportion ; *viz.)*

21 : 11 : : the Cube of the Diameter ; ſolid Content.

5. *The find the Number of Times, that any of the heavenly Bodies are greater or leſs than the Earth.*

(work thus)

1. If the Solidity of any of the heavenly Bodies is greater than the Solidity of the Earth, divide the greater Solidity, by the Solidity of the Earth, and the Quotient is the Number of Times, that ſuch heavenly Body is greater than the Earth.

2. If the Solidity of any of the heavenly Bodies is leſs than the Solidity of the Earth, divide the Earth's Solidity, by that leſs Solidity, and the Quotient is the Number of Times, that ſuch heavenly Body is leſs than the Earth.

The *Orrery*, in its greateſt Perfection, is contrived to move by Clockwork, as was ſaid before; *i. e.* by turning a ſmall Winch, the whole is ſet in Motion, in ſuch a regular Manner, and in ſuch Proportions of Time, one to the other, as thoſe great Bodies really move in the Heavens: But, as ſuch an one is extremely dear, and not to be purchaſed for ordinary ſcholaſtic Uſes, a ſmall manual one will ſerve for moſt Purpoſes, and give as many Solutions as may be convenient for the Pupil at the Time of Inſtruction.

By this Inſtrument, appears all Sorts of Eclipſes, whether Lunar, Solar, or Planetary, as alſo the Eclipſes of the Satellites, both of *Jupiter* and *Saturn*; all which, together with the Tranſits of *Mercury* and *Venus*, are very eaſily accounted for; and the true Cauſes of them ſo very plain, that almoſt a Child may underſtand them.

The direct, retrograde and ſtationary Motions of all the Planets, both inferior and ſuperior, are all diſtinctly ſeen, and the Reaſons of thoſe Motions, at the ſame Time, made appear ſo evidently by the Inſtrument itſelf, that Words can't do it ſo well.

The annual and diurnal Motions of the Earth are here clearly ſeen, together with the increaſe and decreaſe of Days and Nights.

The ſeveral Phaſes or Appearances of the Moon, and her irregular Motions in her Orbit, are here likewiſe made very plain and eaſy to the Pupil.

Mercury and *Venus*, by moving them round, will appear to make their Orbits, within the Orbit of the Earth; and therefore they are ſometimes between the Earth and the Sun, and ſometimes beyond the Sun. When they are between the Earth and the Sun, their Motions are then retrograde, but when they are beyond the Sun, their Motions are direct. It will alſo appear, that at the Earth *Mercury* never makes an Angle with the Sun greater than 28°, nor *Venus* more than 48°.

That the Planets, *Mars* and *Venus* (the Orbit of the Earth being between their Orbits) will ſometimes be very near the Earth, and ſometimes very remote from it; in conſequence of which, when they are neareſt to the Earth, they muſt appear largeſt and ſhine brighteſt; and ſmalleſt when moſt diſtant from it.

If a ſmall Lamp be made, and put in the Place of the Sun, with ſuitable convex Glaſſes to give a ſtrong Light, without any other, it will then repreſent that glorious Luminary; then may the Moon be put in Motion, and the ſeveral Phaſes from New to Full, and from thence to New again, will appear in a very pleaſing Manner, and alſo the contrary Phaſes of the Earth to the Moon: and theſe, juſt as they appear to the Inhabitants of each Orb.

Beſides the Eclipſes of *Jupiter* and *Saturn*; by the Help of the Lamp, ſeveral pretty Phenomena may be exhibited, with their Satellites; *viz.* by putting them in Motion, and then obſerving how thoſe Satellites are immerged, and as it were loſt in the Shadows of their Primaries, and afterward by the continuance of their Motions, how they are again emerged, and the Sight of them regained; tho' theſe Phenomena are better exhibited by the Clockwork *Orrery* than by the Manual one.

With regard to *Saturn* and his Ring, the Space between them is diſcovered very eaſily: for, as the Ring is made to turn, as it were, upon an Axis, that Space may ſometimes be ſeen thro', and the whole Ring appear in its full Breadth and Circumference, and ſometimes like a ſtraight Line running a-croſs its Primary, both perpendicularly and horizontally.

To ſum up all. The whole of the *Orrery* is ſo very plain and inſtructive, that its uſefulneſs is beſt ſeen and explained by the ſtudy of the Inſtrument itſelf; neither can any thing give ſuch juſt and eaſy Notions of that Syſtem of *Aſtronomy*, which is now univerſally received (and which our Youth ought to be acquainted with) like that Inſtrument, which is called the *Orrery*.

THE END.

ERRATA.

Page 4 Line 18 for × put +.
19 for 42021805 put 42028805.
6 —— 47 for *moves* read *move*.
11 —— 25 for *Artic* read *Arctic*.
25 —— 27 for *or* read *called*.
26 —— 8 for *Magaaoxa* read *Magadoxa*.
27 —— 4 for *I and* read *Land*,
28 —— 34 for *becouſe* read *becauſe*.
43 —— 2 for ♍ read ♏.
53 —— 31 for *Ephemaris* read *Ephemeris*.
54 —— 24 for *centra* read *central*.
63 —— 33 for *into equal Parts* read *into two equal Parts*.
65 —— 17 for *there ore* read *then it*.
69 —— 21 for *incluſive* read *incluſive*.
78 —— 19 for *ve* read *have*.
83 —— 12 for *D given egrees* read *Degrees*.
118 —— 35 for *Cormandal* read *Caromandel*.
131 —— 3 for *Biſext* read *Biſect*.
ib —— 4 for *Subtile* read *Subſtile*.
143 —— 2 for *Erietbonius* read *Erichthonius*.
150 —— 41 for *Vendemiatrix* read *Vindemiatrix*.
145 —— 22 for *of the &c.* read 4. *Of the &c.*
182 —— 20 for *Jupiter* read *Saturn*.

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The System of Tycho Brahe

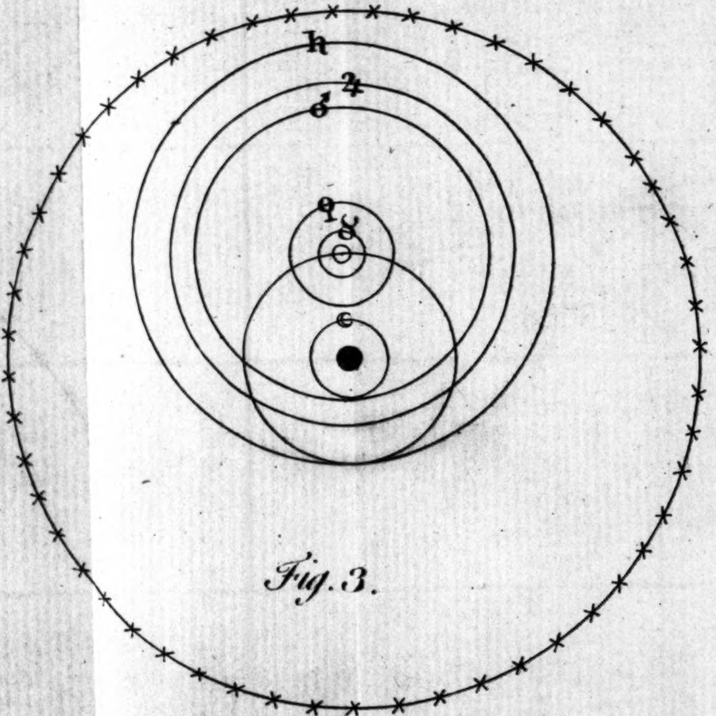


Fig. 3.

The System of Ptolemy

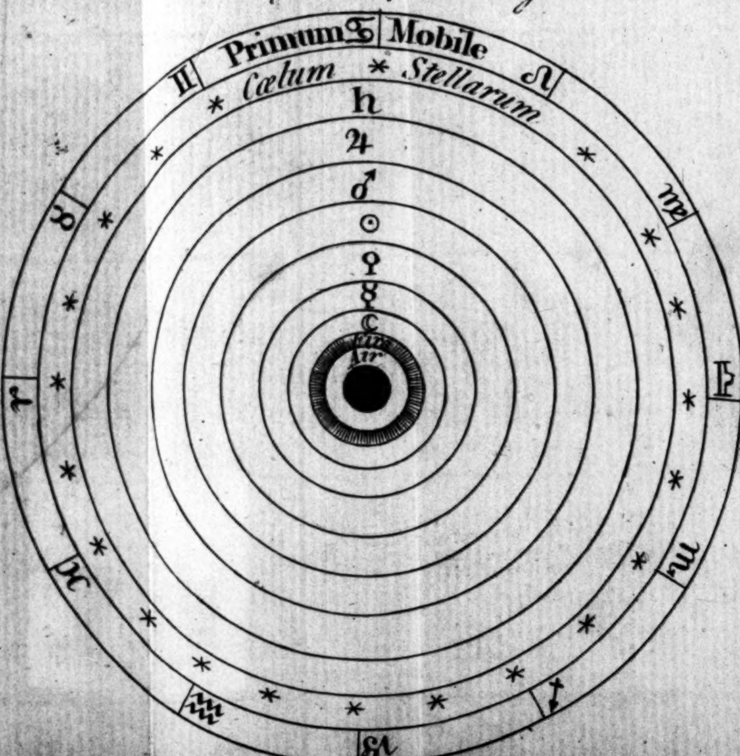


Fig. 2.

Pla. III.

The System of Copernicus

With the Orbit of a Comet and the Satellites of Jupiter and Saturn

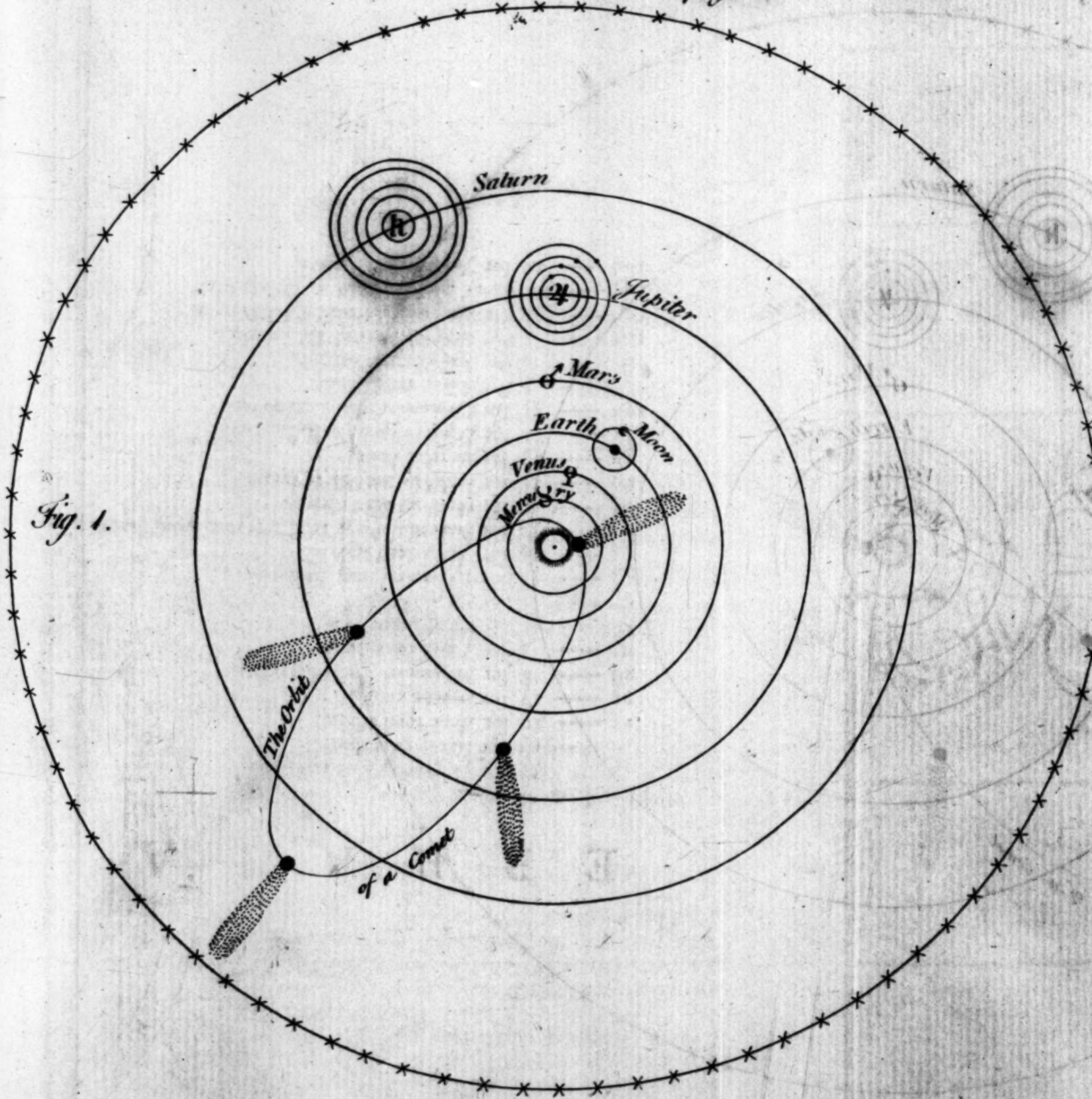


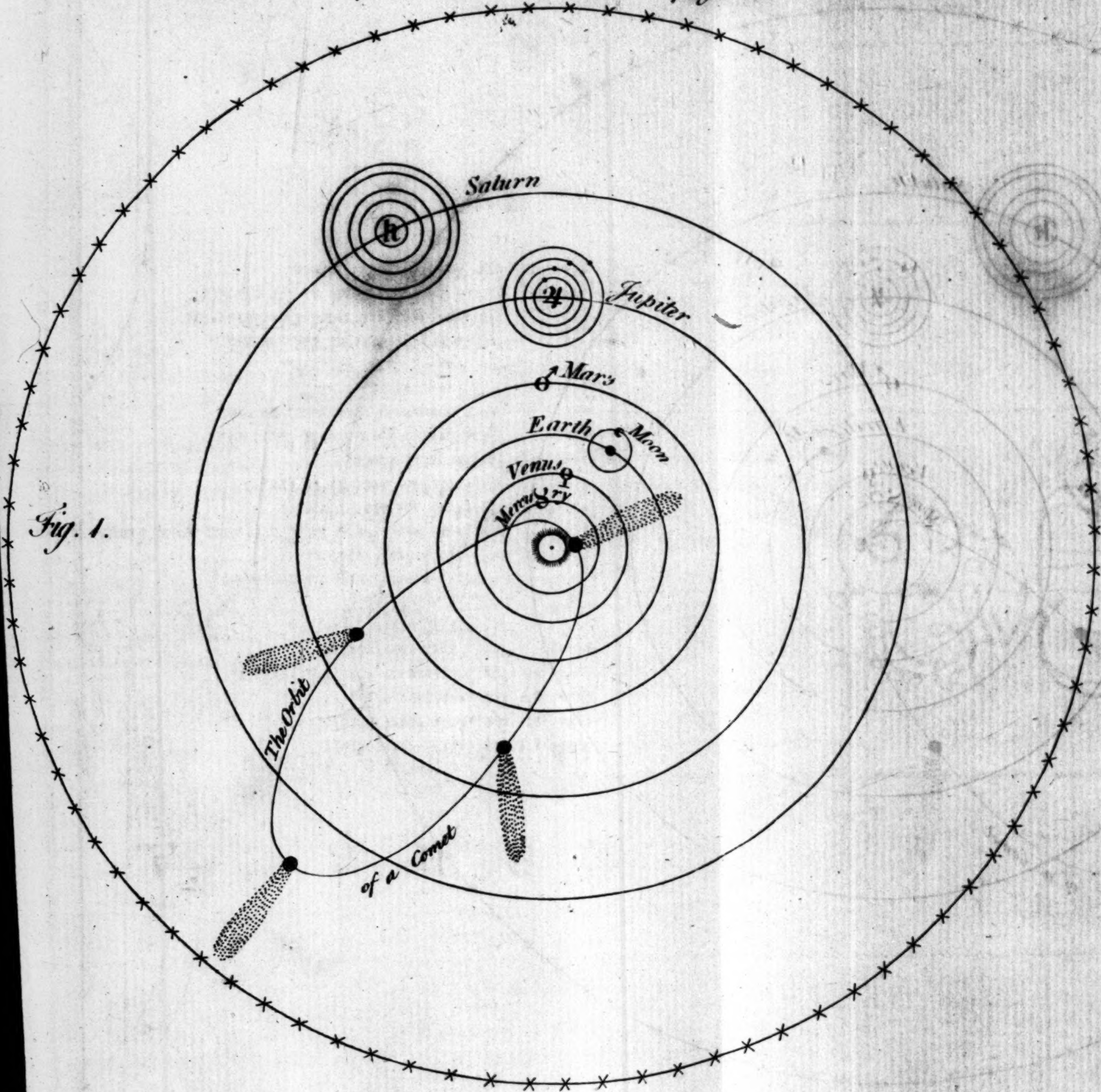
Fig. 1.

Pla. III.

The System of Copernicus

With the Orbit of a Comet and the Satellites of Jupiter and Saturn

Fig. 1.



The System of Tycho Brahe

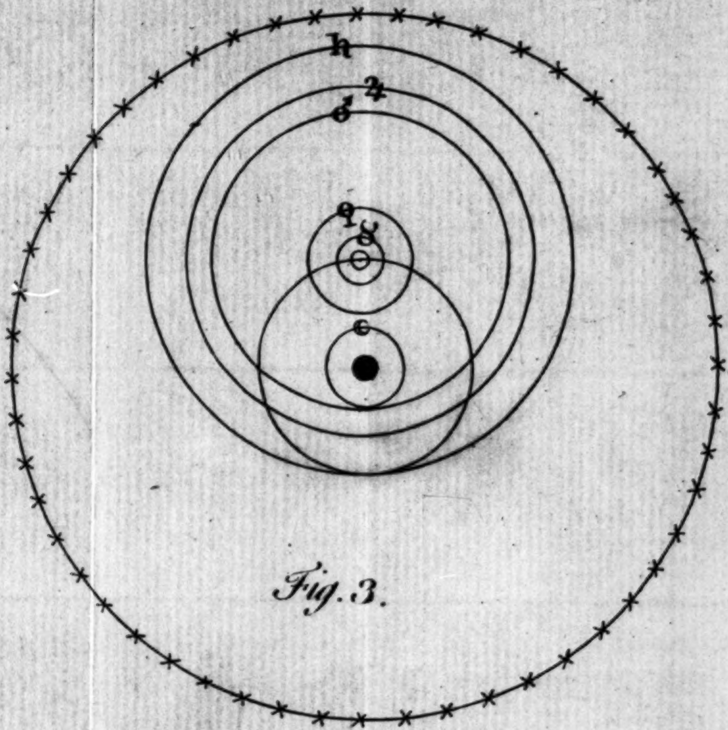


Fig. 3.

The System of Ptolemy

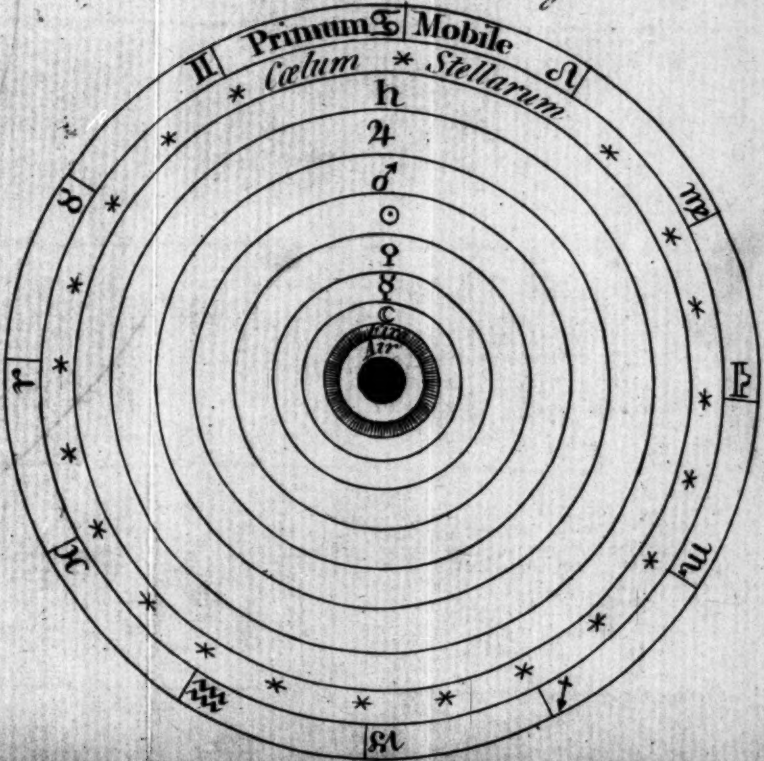


Fig. 2.

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Pla. II.

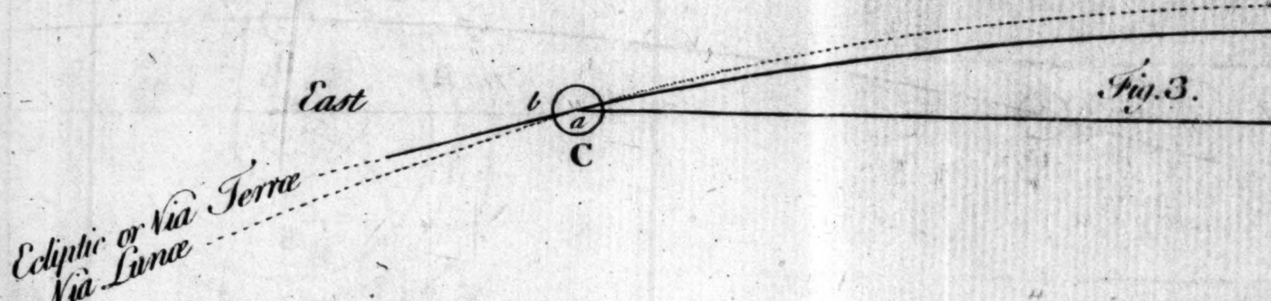
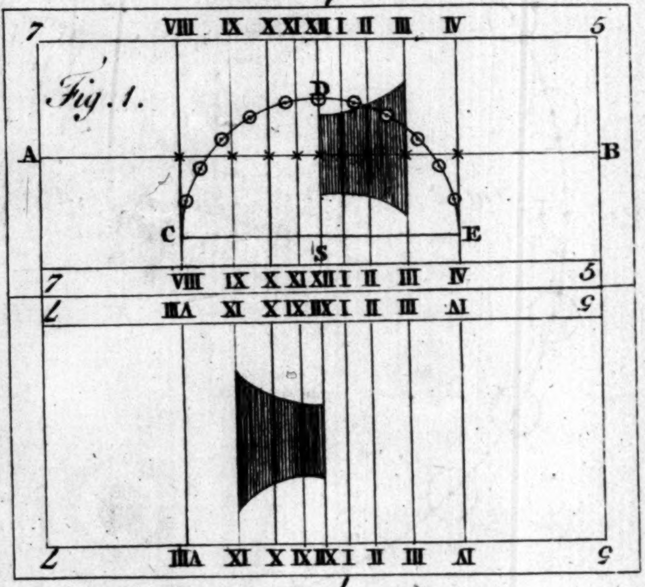


Fig. 3.

Equinoctial Dial

The Front of the Dial



The Back of the Dial

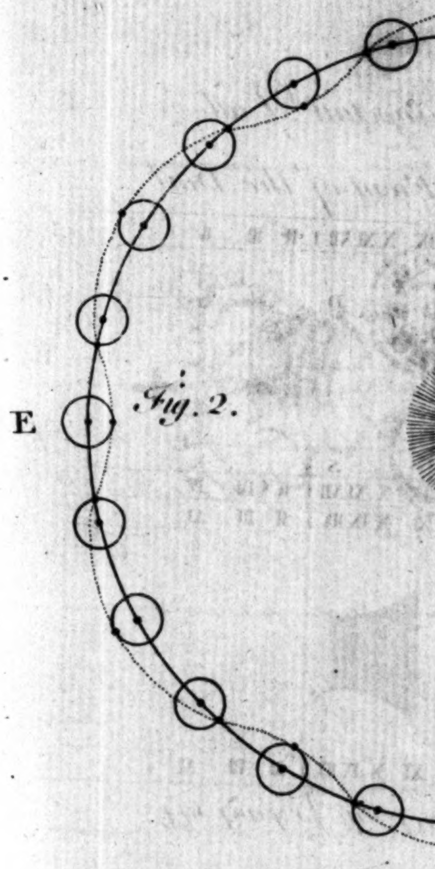
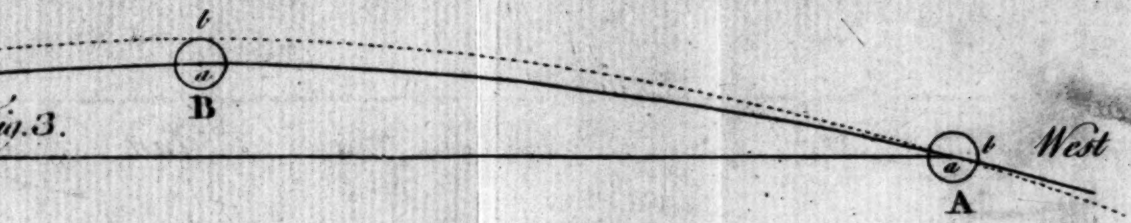
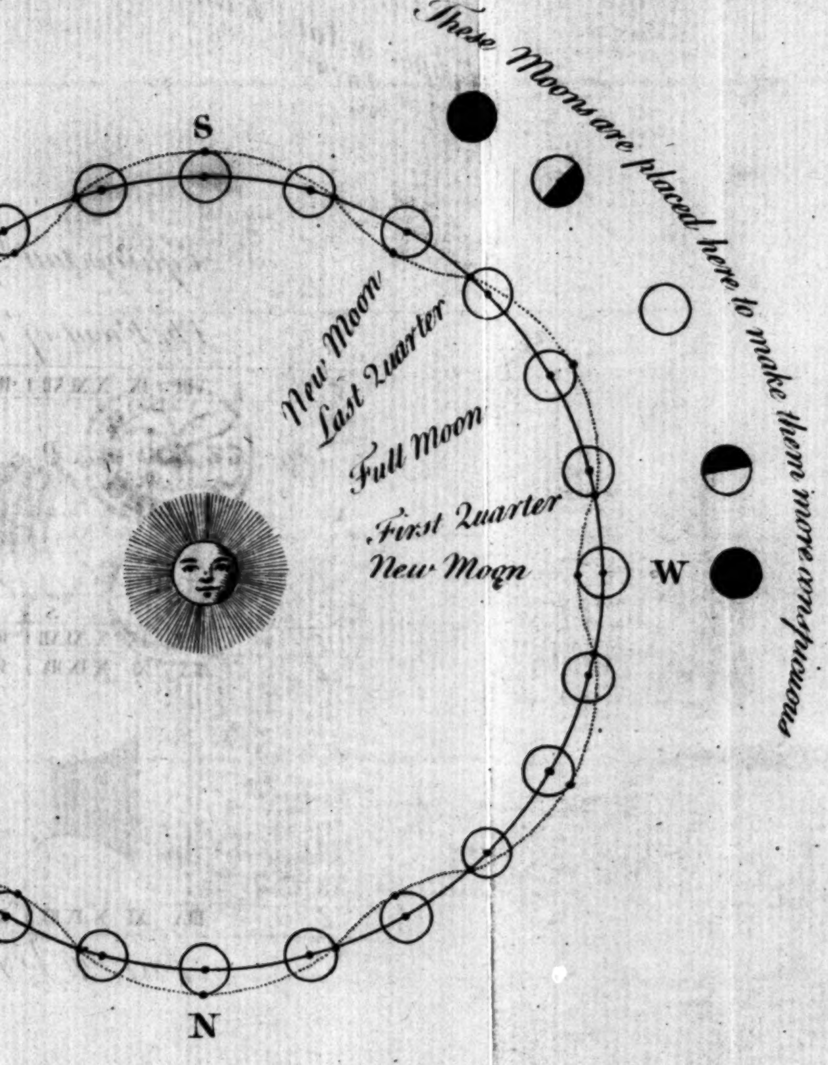


Fig. 2.

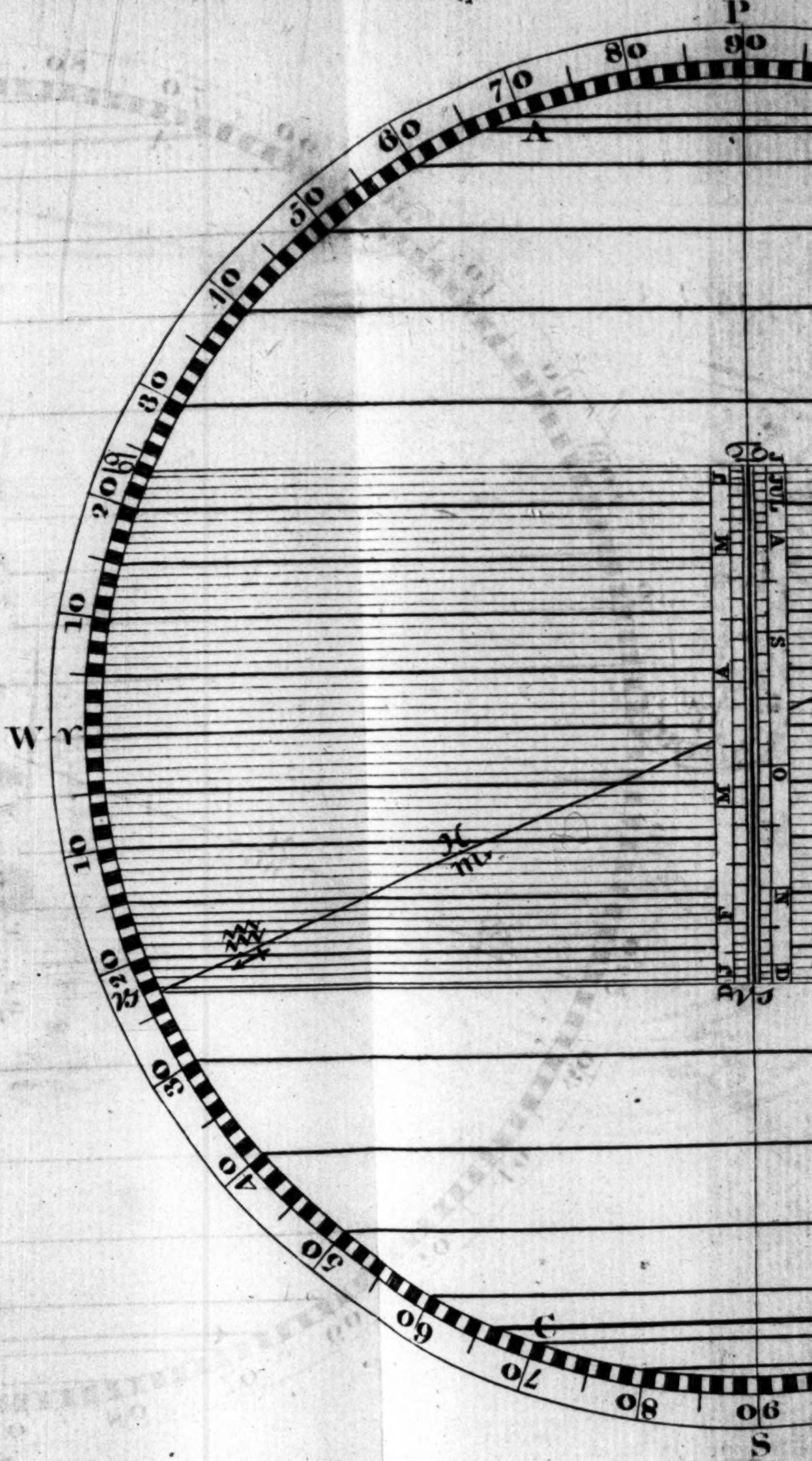

b
a
B
West
b
a
A

ig.3.


These Moons are placed here to make them more conspicuous
S
New Moon
Last Quarter
Full Moon
First Quarter
New Moon
W
N

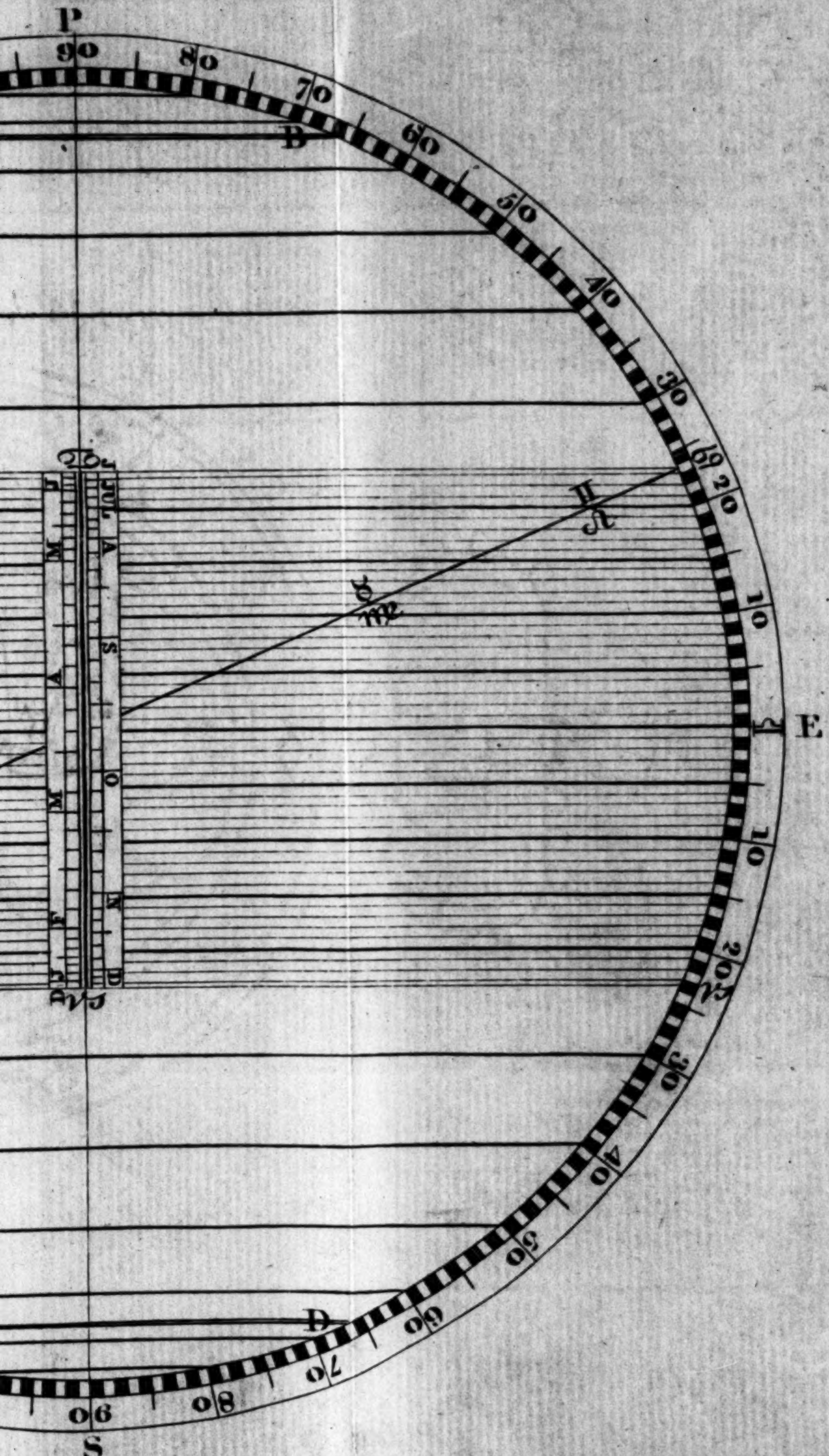
Pla. I.

The Anale



Analemma

to face Page 80.



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